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[621. 337]

Safety device for railway trains and vehicles operated by one man [1],

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As a result of the difficult economic position the railway industry has had to face during recent years, it has become necessary to see what economies can be made in operating costs. Amongst the items of greatest magnitude is the cost of wages which have grown so greatly, though not so much through any intrinsic necessity due to the methods of working used as to the obligation of following regulations of old date. For example: the very marked contradiction between the excess of precautions imposed so far on the railways requiring two men on the locomotive, a guard, at least one brakesman at the rear of the train made up of two or three vehicles, running on its own track, fitted with automatic brakes carrying some tens of passengers, and the total absence of requirements and the great latitude allowed in the case of the operators of road services who run heavy road vehicles driven by one man, frequently at excessive speeds on roads commonly used by other vehicles and foot passengers, is very striking.

We have, however, no intention of considering how far the requirements now in force, regulating the movement of trains, can be simplified or altered, nor the general thesis if the working of a railway train fitted with the automatic brake, when confided to one man, should or should not be subjected to restrictive regulations such as, for example, the obligation of fitting a special device known as the *dead man's handle*, whereby the brake is applied automatically and the train stopped if for any reason the driver releases the control.

We shall content ourselves with showing that if the use of a special safety device is considered essential when the train is handled by a single employee,

(1) Translated from the Italian.

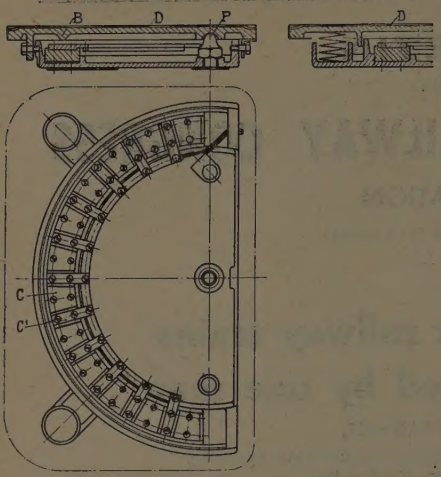

Fig. 1.

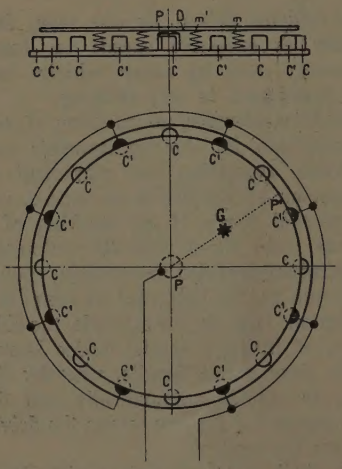

Fig. 2.

the *dead man's handle* arrangement should contain in itself not only the fullest guarantees as regards safety in action and freedon from change in function, but should in addition be favourably received by the staff.

Principles of construction of the devices in use up to date.

The different arrangements known as the *dead man's handle* demand of the driver a continuous or intermittent action on a push button, pedal, or lever etc. If, for any reason, this action fails, an automatic device comes into action and first of all cuts off the power supply (opening the main switch in the case of electric locomotives, closing the regulator of steam locomotives) and then applies the brake. Depending upon the type of fitting used, the action causing the train to stop shows itself either at the end of a given time interval or after the vehicle has run a certain distance from the moment at which the continuous or intermittent action of the driver ceased.

It frequently happens, however, that the driver, to avoid the bother and the constant attention of the continuous or intermittent action on the push button, pedal, or handle, etc., is tempted to substitute for the action or movement he should make, some outside means (weight or rough and ready tackle giving a continuous or intermittent effect) in order to be free to move about whilst avoiding stopping the train.

It is quite true that some forms of the « dead man's handle » are so arranged that any change tending to replace the driver's action by any artificial means is almost impossible or at least most difficult to carry out. For example there are devices with which, if the train is not to stop, the driver must press down at short intervals, such as every 5 or 10 seconds, a push button or a pedal or move a lever

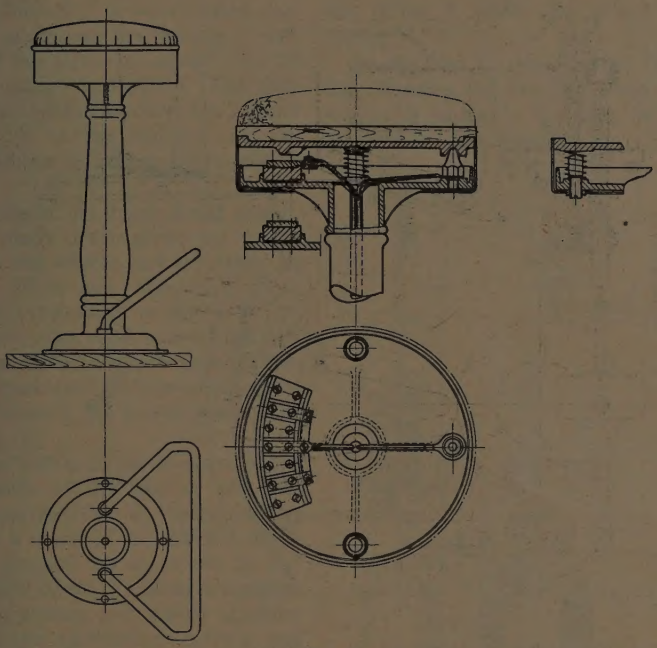

Fig. 3.

in a certain position, operation more difficult to carry out with improvised means.

Furthermore, devices of this kind, even if they do not require any great effort, obviously tire the driver and act as an annoyance.

Some people consider it undesirable and objectionable from a humanitarian point of view to impose on the driver this forced and frequent movement which in nature is comparable with the involuntary movements due to nervous complaints.

Another arrangement has been suggested which consists of a belt the driver has to wear and which is connected by a cord to a mechanical device which can open the switches and apply the brakes. Although this arrangement has been designed so as to enable the driver to move across the cab, he is tied up rather like a dog on a leash.

New safety device.

Starting from the premises given above, we have designed the arrangement described below, basing it on the following principle.

The driver standing on a step or seated on a folding seat near the regulator has to conserve his vertical position and instinctively is obliged to move his own

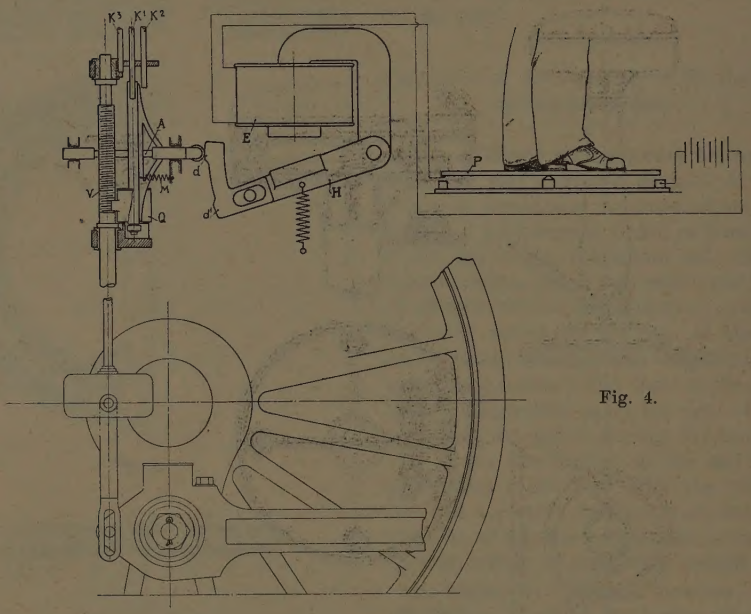

Fig. 4.

centre of gravity either as required to operate the different appliances or to react against the movements of the vehicle in motion tending to throw him off his balance.

In the case in which the driver is standing up, the arrangement consists of a step composed of a part rigidly fixed to the floor of the vehicle and a second part on which the driver stands and which can make relatively to the former the small movements set up by the driver.

These small movements cause the intermittent closing of an electric circuit. If contrariwise the driver leaves his normal position through sudden illness and, fainting, falls clear of the step, or even on it (lowering thereby his own centre of gravity very considerably) the intermittent closing and opening of the electric circuit no longer takes place and the current is either permanently off or on.

Figure 1 shows one of the types of step adopted. D is the moveable part, semi circular in form, the centre bearing on the pivot P, whilst the edge has a rim B bearing on the small blocks C, and C', alternatively insulators and conductors, fastened to a semi-circular ring carried on the fixed part of the step.

With this arrangement, the contact between the fixed and moveable parts occurs at the Point P' of intersection of the circular ring of the contacts and the line joining the pivot P and of the projection G of the centre of gravity of the conductor on the plan of the step (fig. 2). This projection can correspond either

with a live contact C′ or an insulated contact C : in any event, the instinctive movements of the driver cause the point of contact to change continually. The electric contacts mentioned above are formed of studs made of iron and are not subject to wear nor do they require adjustment.

In the case of the driver being seated, the seat is made of *two* parts, one rigidly attached to the vehicle and the other on which the driver seats himself, free to move slightly relatively to the first. In this case also, the rigid part of the seat carries the contacts which make intermittent contact with the moveable part of the seat following the movements of the driver (fig. 3).

The wire which comes in front of the fixed contacts of the step or seat and which consequently is intermittently earthed as a result of the driver's movements, is coupled up as shown in figure 4, which shows the general arrangement of the system, to a supply of either continuous or alternating current and then to the apparatus which causes the vehicle to be stopped after running a given distance.

Figures 4 and 5 show, in diagram form, one form of the appliance which causes the supply of energy for the propulsion of the vehicle to be cut off and the brakes to be applied when the current in the connecting wire to the step is either permanently on or off through failure of the normal action of the driver.

The electro-magnet E is fed by current switched on or off by the contacts P of the step or seat. This electro-magnet attracts a core H having studs *d*, *d′*, which in the position of attraction or repulsion push the bar A towards the screw V whereas in an intermediate position of the core H the bar A is kept away from the screw V under the action of the spring M.

On the bar A, able to slide freely in the direction of the bar itself, is the weight Q which in the part facing the screw V is screw-threaded.

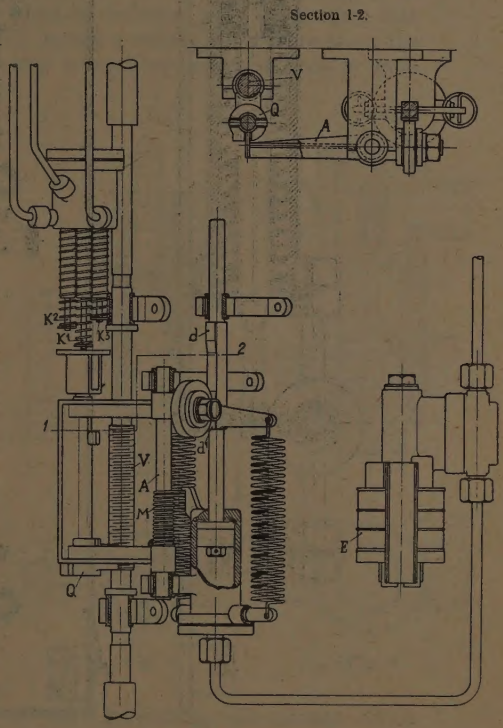

Fig. 5.

The screw V is rotated always in the same direction by any motor running at constant speed independent of that of the vehicle (acting on a time basis), or if preferred, as shown in figure 4, by mechanical drive (which may be the same as that for the speed recorder) from the

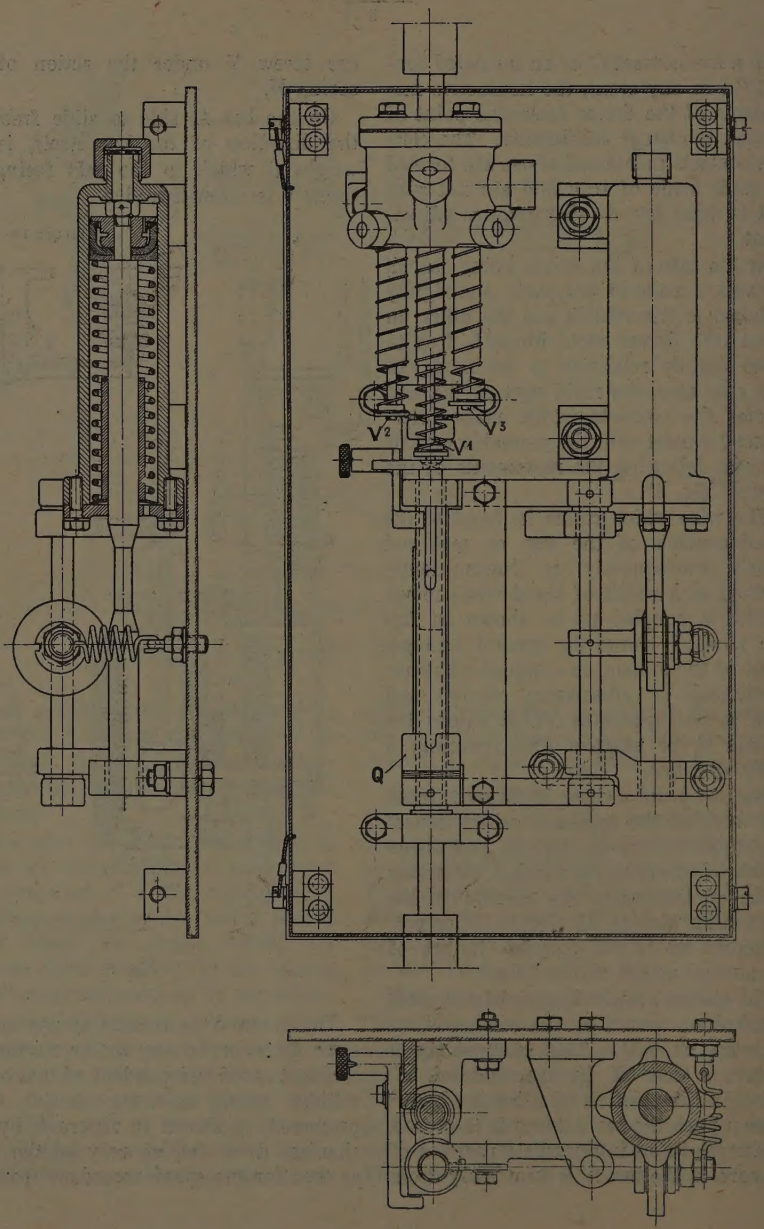

Fig. 6.

wheels (acting on a distance travelled basis).

It will be readily understood that when the electro-magnet E is energised or de-energised permanently, the weight Q, pressed towards the turning screw V, engages with it and is lifted at a speed proportional to the pitch of the thread and to its speed of rotation. If nothing occurs to modify the current following in E the weight Q is raised to Q′, that is to say to the end of the thread. During the movement the weight Q first of all comes in contact with the point K_1 at which a valve or an electric contact operates a warning signal (whistle, bell, etc.) which calls the driver's attention to the action on the switch and brakes about to take place. If after this warning the driver does not act instinctively or voluntarily on the step or seat or on a special push button placed near at hand, the weight Q continues to rise until it gets to the point K_2 where it operates another valve or electric contact which opens the switch or cuts off the motive power. Ultimately the weight Q reaches the point K_3 where it operates the valve or electric contact causing the application of the brakes on the vehicle.

So long as the weight Q does not reach the point K_1 (at which the warning signal operates) there is a possibility, through movement of the step or seat due to the driver, of the electro-magnet being slightly energised or de-energised : the weight Q then immediately moves away from the screw and again falls in order to begin to rise again. Obviously the weight Q will only succeed in completing its full travel and make the contacts K_1, K_2, K_3 to operate the alarm signal, cut off the power and apply the brakes, if between time the driver makes no movement of appreciable extent.

It will readily be understood that with a suitable pitch of thread of the screw V, and distance and shape of the contacts of the step or seat, it is possible to arrange for the weight Q never to complete its stroke so long as the step or seat carries a living body acting against the shocks and movements of the vehicle causing it to loose its balance. It is also evident that if during a certain time, there is on the step or seat an inanimate body or even

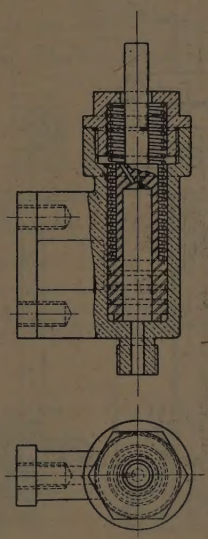

Fig. 7.

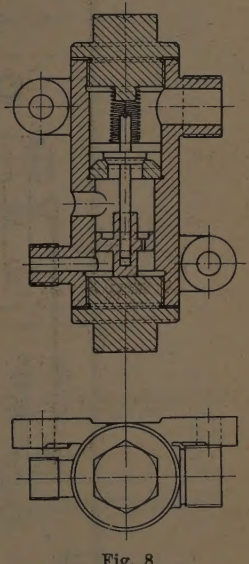

Fig. 8

if there is nothing, the current which should energise the electro-magnet will remain either cut off or on and the weight Q will complete its full travel.

In order to still further increase the driver's liberty of action and to enable him to leave the usual driving post to examine some part of the locomotive, one or more buttons corresponding with the parts in question are provided and the

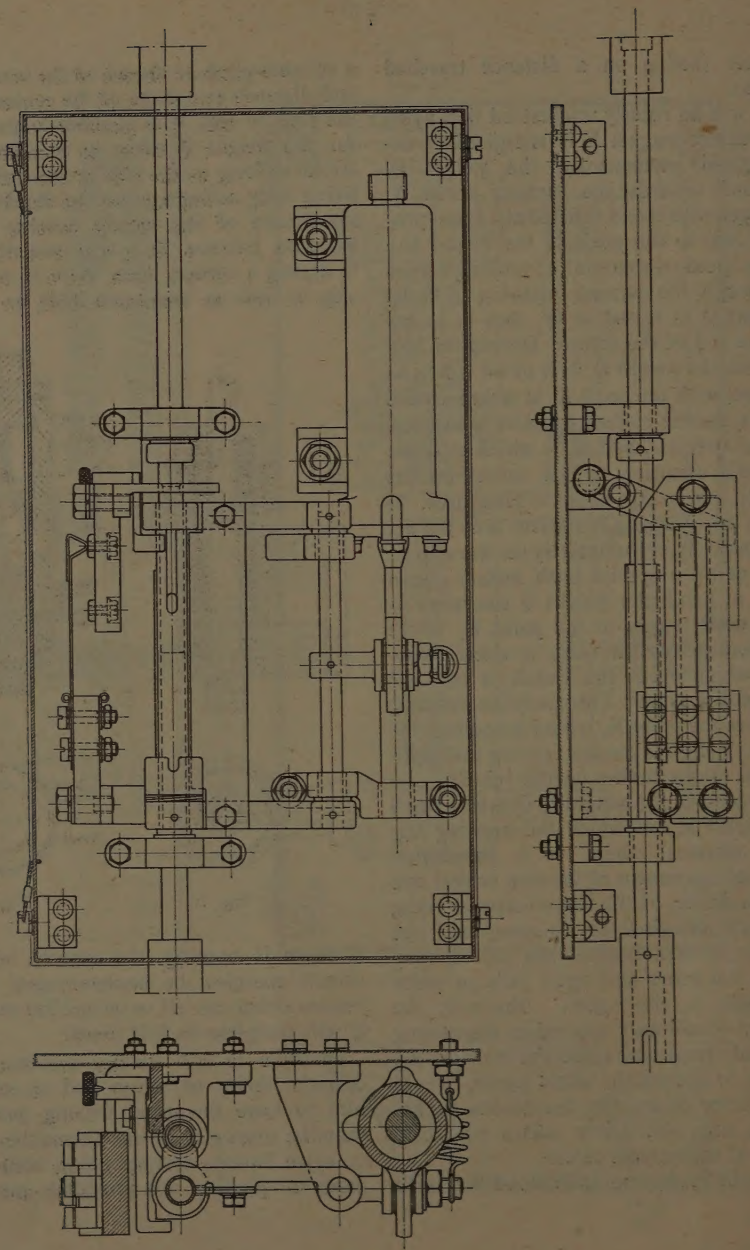

Fig. 9.

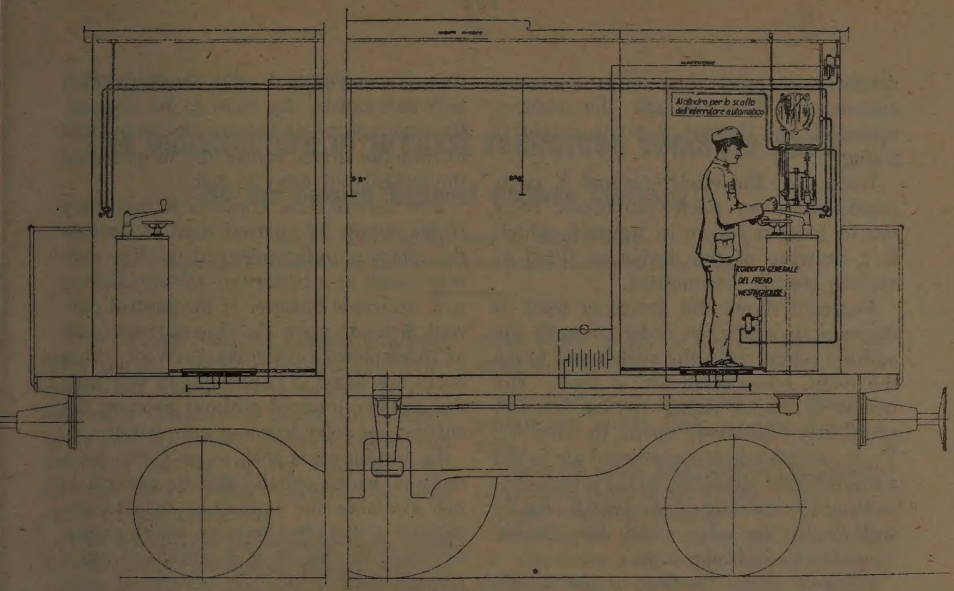

Fig. 10.

Explanation of Italian terms:

Al cilindro per lo scatto dell' interruttore automatico = To the cylinder by the release of the automatic cutting-out switch. — Condotta generale del freno Westinghouse = Main Westinghouse brake pipe.

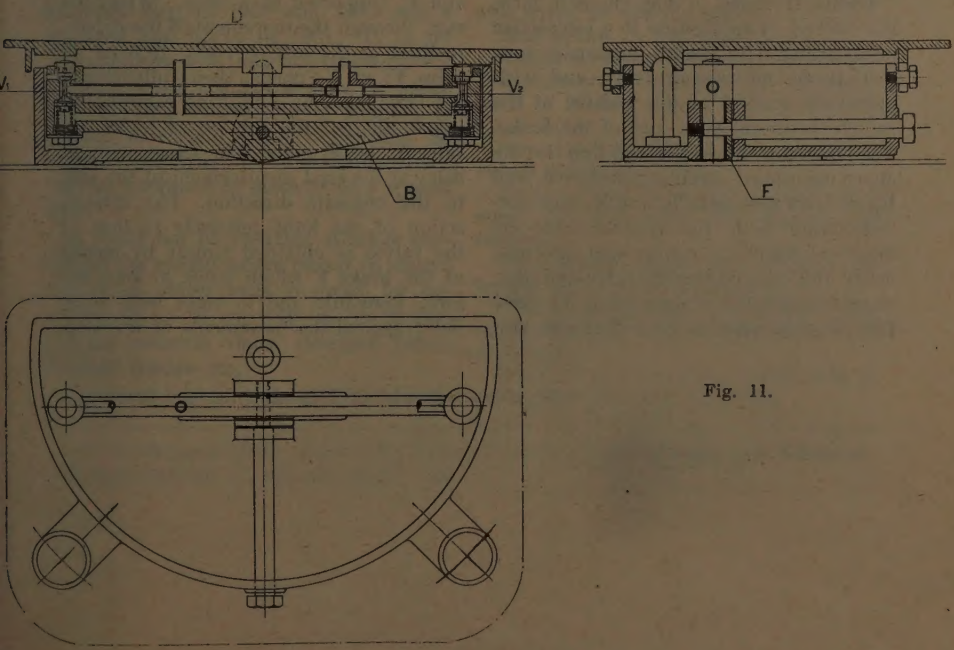

Fig. 11.

driver must press them down to cause current to flow through the electro-magnet E and thereby stop the weight Q rising.

Instead of the electro-magnet E mentioned above an electro-pneumatic relay can be used as shown in figure 5, which is a drawing of the device as fitted to various electric locomotives.

Figure 6 shows the device as used in the case in which, in order to work the audible signal, open the switch and brake the train, compressed air is used. The weight Q whilst rising (by an amount previously regulated) opens in turn V_1, V_2, V_3, which admit compressed air to the audible signal (whistle), to the piston controlling the opening of the switch (fig. 7) and finally the valve which lets out air from the main brake pipe.

Figure 9 shows the type of electrically controlled appliance for the signal, the switch and the brake. Obviously by using electrically operated valves the control could also be electro-pneumatic.

Figure 10 shows in diagrammatic form the method of application to a locomotive of a fitting with electro-pneumatic control of the cutting-out relay, and with pneumatic control of the whistle, of the switch throw-out gear, and of the brake. The diagram shows, in addition to the above mentioned, auxiliary pushes B_1 and B_2, two two-way cocks R_1 and R_2 each corresponding with the control table by means of which air can be sent intermittently into the cutting-in relay cylinder, should the supply of current to the relay fail. In this event, at the end of a certain time, the cutting-out relay comes into action and causes the train to be stopped. By opening one of these cocks from time to time the driver causes the weight Q of the cutting-out relay to fall.

The use of these cocks is unnecessary if the supply of current used to operate the relays is independent of the line current (such as a battery of accumulators); it is desirable however if the control current depends upon the line current (case of three-phase locomotives). When these cocks are fitted it is possible to run with the trolleys lowered without causing the cutting-out relay to come into action.

In certain cases such as on steam locomotives, where usually electric current is not available for operating the electro-magnet or the electric valve which causes the train to stop, it is desirable to use a pneumatically controlled pattern of step. Figure 11 shows in diagram form a step of this kind.

The lower wall of the step is in contact with the spindles of the two valves V_1 and V_2 supported by a lever. When the step, through the movement of the driver, inclines to the left or right, first of all valve V_1 or V_2 opens, then fully closes, the lever takes up a position corresponding to that of the step so as to let the valve V_2 or V_1 come into action without delay at the least displacement of the step in the opposite direction. The delayed action of the lever relatively to that of the valves is obtained simply by means of the brake F which tends to keep the lever immobile and to react with some delay against the movements of the step.

[691 (.493) & 721 .9 (.493)]

The manufacture of precast reinforced concrete parts

on the Belgian National Railway Company [1],

by C. LEMAIRE and J. SCHOTTE,
Engineers, Permanent Way Department of the Belgian National Railway Company.

The Belgian National Railway Company first started the manufacture of precast reinforced concrete parts in 1927 as a result of a quantity of worn out wooden parts such as fences, platform edges, and trunking having to be renewed, and through there being available a large stock of raw materials.

The advantages of making such parts in reinforced concrete, as regards life, appearance, cost of manufacture and repair, over similar details of other materials are well known; as a result the yard built at Roulers by the Company has steadily grown. This yard employed about a hundred men in 1929 and 1930 and a hundred and thirty in 1931. It in no way competes with the many Belgian firms manufacturing reinforced concrete parts. The working programme at Roulers is limited to certain parts which may be urgently required or are difficult to supervise, awkward to make or of a special type.

It could not be justified at other centres on the system, where labour in scarce, nor if its object were to make, for example, 30 × 30 cm. (12 in. × 12 in.) pressed concrete slabs, standard pipes, window frames, etc.

A railway has many places in which concrete either plain or reinforced can be used successfully :

Boundary posts to replace old sleepers which are costly and of poor appearance;

Concrete posts and open work panels to replace fencing in wood;

Plain concrete fences;

Posts of all kinds along the lines such as : kilometre and hectometre posts, level crossing and « caution » posts, gradient posts, curve posts, and dwarf signal posts;

Blocks for curve checking and land boundaries;

Channels carrying signalling cables and wires, or heating pipes;

Side drains in bad ground;

Standard reinforced pipes for culverts;

Demountable sections of retaining walls of loading ramps, coal stacks, and scrap bins;

Removable sections for ordinary and raised platforms;

Flower vases for station gardens, and more or less elaborate flower bed edgings;

Demountable bins with screens for ballast used in shovel tamping;

White boards used in signalling by position indication and for signalling level crossings;

Foundations of various kinds used in connection with the signalling.

(1) Development of the report made to the first International Concrete and Reinforced Concrete Congress at Liége, September 1930.

Some of the above parts have only been made as an experiment; we think, however, that after the designs have been properly standardised an increasing use will be made of them.

* * *

A yard for the manufacture of standardised parts in reinforced concrete owes its principal advantages to the economies in labour and material series production procures. The principal of these are :

1. The manufacture in a special yard of reinforced concrete parts is much more carefully done and with much less labour than in a general yard, seeing that special plant and facilities such as concrete mixers, hoppers, cranes, etc. can be provided and that the test cubes for controlling the quality of the concrete can be easily taken.

2. The raw materials, such as sand, gravel or broken stone, cement and steel can be off-loaded and the finished product loaded up with the minimum of cost, provided that the yard is connected by a siding to the railway and is suitably equipped with the necessary mechanical appliances.

3. There is no loss of raw material, unlike the frequent experience in general yards and in temporary yards set up along the line.

4. Water being laid on enables the concrete to be mixed automatically with the correct quantity of water and so reduce the labour cost.

5. The costs of timber for the forms and the cost of joiners' wages are very much less than in general yards or yards along the line and it can be taken that wood forms for series production can be used 400 times before getting into too bad order.

6. The output of the men is much greater in a proper yard and this is due on the one hand to the division of work whereby the men become more expert and waste less time, and to the fact that the output can be continuously followed up; the output, moreover, can be stimulated by a premium system.

* * *

A well organised yard should include the following :

Part of the area should be covered in by light shelters to allow the work to be carried on during bad weather: a joiners' shop for making and repairing the forms, a shop for dealing with metal work, a cement store, a railway siding; a system of Decauville lines for carrying the raw material and the concrete parts made, water mains, large open yards for stacking the forms and manufactured parts.

As regards equipment, a concrete mixer (the Roulers yard has two) with loading elevator and measuring devices, a small forge; tools for the men responsible for the reinforcement as well as for the men handling the concrete, such as tongs, pincers, barrows, shovels, tampers, etc., moulds for making test cubes and instruments for measuring the fluidity of the concrete; a fast petrol mobile crane, or monorail cranes, for handling the parts made and for working the stock yard.

It may be said that when the above equipment is available, the cost of reinforced concrete parts made in series is only half what it would be in a general yard or out on the line.

* * *

In the following the organisation of the Roulers yard, for the running of which we are responsible, will be specially described. Although this organisation is intended more particularly for making railway parts, we think it is not without interest from a general point of view. We have attached to this article drawings of the most interesting parts made, and of the reinforcement and moulds used, with photographs to show the appearance of some of the installations made of concrete parts. (We would like to draw attention, at this point, to the intelligent and able assistance we received from the two inspectors, Messrs. Vandevelde and Van Hee, who in turn were responsible for working this yard.)

The operations carried out in this yard are the following :

1. Unloading raw materials;
2. Making and repairing forms;
3. Preparing the reinforcements;
4. Manufacturing, transporting and utilising the concrete, stripping the moulds and stacking;
5. Loading up for removal;
6. Accounting, ordering and testing.

We will now describe them in turn.

Raw materials specification and quality required.

All raw materials are supplied competitively or to public tender according to the ordinary specification of the Belgian National Railway Company. All prices are delivered at Roulers station. In the case of public tenders a special specification is issued.

The following materials are used :

1. *Cements.* — Standard Portland cement to the Belgian National Railway Company's specification is used.

2. *Quick hardening Portland cement* is used during the work as soon as the temperature falls to about 5° C. (41° F.). (We make provision for carrying on concreting during frost by mixing chlorate of calcium in the proportion of 4 % of the weight of water.)

Sand. — Rhine sand can be supplied at Roulers as cheaply as pit sand and is often of better quality. The nearness of the port of Ghent where the Rhine sand is handled mechanically is the reason for its cheapness.

For reasons of economy we only use the ordinary run of sand; it is of very good quality as regards purity and size. It fully meets as regards fineness the requirements of the Belgian Standards Association for concrete structures.

We have also used pit sand from Brabant; its grade of fineness is only 1.75 which detracts from the strength of the concrete (see test results). The sands from the Limbourg pits are often of excellent quality but have never been supplied although we have invited competition. Porphyry dust has only been used very occasionally in place of sand: it does not seem to adhere together so well as sand and the forms cannot be removed as soon as desired.

5/20 mm. (3/16 in. — 13/16 in.) porphyry chippings. — 2/5 mm. (5/64 in. — 3/16 in.) porphyry small chippings. — The 5/64 in. — 3/16 in. size is used for the finer quality products and the 3/16 in. — 13/16 in. for ordinary work; with each of these materials the strength of the concrete is very good (see tests). The cleanliness and uniform size of this material are well known. The 0/20 mm. (0 in.

— 13/16 in.) size is, we think, of much less value as it contains too high a proportion of fine and is not uniform.

Rhine and Meuse gravels. — These gravels are much alike as regards quality and price.

We have used 5/30 mm. (3/16 in. — 1 3/16 in.) size pebbles when short of porphyry chippings or broken gravel, which latter is only supplied by a few firms. The tests clearly show that concrete made with pebbles is not so strong as that made with broken stone.

We think this lack of strength will be more obvious in thin parts wherein large stones might break the continuity or produce « nests » in the mass of concrete.

Recently 3/8 mm. (1/8 in. — 5/16 in.) size gravel has been supplied; this grade of fineness would be more suitable for thin walls; we are making tests and are hopeful of obtaining good results.

The major part of the details manufactured in reinforced concrete at the yard need not be of great strength in themselves if they were not liable to shock during transport or when being handled. We think, however, that in view of the very small difference in price it is always better to use broken stone and good sand of a fineness grade higher than 2.

Granulometric sizes of inert materials.

A yard producing annually several thousands of cubic metres of concrete can with advantage pay particular attention to the sizes of the inert materials to be used.

Reinforced concrete parts for railway use are often subjected to compression, simple or compound bending, and even to shock.

As Mr. R. Dutron (2) has shown in the interesting report he read in September 1930 at the first International Concrete and Reinforced Concrete Congress at Liége, the most suitable composition of the concrete varies with the method of stress. From the point of view of *strength in compression,* Rhine or Meuse shingle and sand give almost the same results. The diagrams Mr. Dutron published show that in the case of concretes of equal cement content, no matter what the content may be, porphyry, slag or sandstone dust mixed with 5/20-mm. (3/16 in. — 13/16 in.) porphyry slag, or sandstone chippings, the *strength in compression* is always very low as compared with that of concrete made of river gravel and sand. If this dust be replaced by Rhine sand the concrete is of practically the same strength (especially when 3 months old) as concrete made of Rhine or Meuse gravel and sand. Concrete made of blast furnace slag with dust, or of sandstone with dust, is definitely inferior in quality to that made of porphyry or gravel with Rhine or Meuse sand. It is however more or less a matter of indifference when using good coarse sand, whether Rhine or Meuse gravel or broken stone of reasonable hardness (porphyry, slag, or broken Meuse gravel) be used.

The strengths are found to be almost the same although those, when rounded materials are used, are still slightly better.

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(2) See DUTRON : « Inert materials and the mechanical properties of concrete » (Publications of the *Technique des Travaux*, 196, rue Grétry, Liége). Paper published by the International Reinforced Concrete Congress, 1930, at Liége.

Results of compression tests.

Description.	Age, days.	Cement kgr. (*lb.*).	Rhine sand.	Brabant sand.	Porphyry chippings (3/16 in.- 13-16 in.).	Porphyry chippings (5/16 in.- 1 13/16 in.).	Round Rhine gravel (3/16 in.- 1 3/16 in.).	Average of 2 tests. Strength in kgr./cm² (*lb per sq. inch*).
			← Litres (*cubic feet*) →					
Concrete No. 1	63	350 (772)	400 (*14*)				800 (*28*)	163 (2 318)
— — 2	61	350 (772)		400 (*14*)			800 (*28*)	146 (2 076)
— — 3	59	350 (772)	400 (*14*)		800 (*28*)			270 (3 840)
— — 4	57	350 (772)		400 (*14*)	800 (*28*)			174 (2 475)
— — 5	54	350 (772)	400 (*14*)			800 (*28*)		235 (3 342)
— — 6	51	350 (772)		400 (*14*)		800 (*28*)		146 (2 077)

The following conclusions can be drawn from these tests :

1. Having regard to the small difference in price of a Rhine sand or of other sand of fineness above 2, compared with finer sands, the first can be used with advantage.

2. It is better to use broken stone and of uniform size if the price is not too high.

3. Concrete made with very fine gravel of the 2/5 mm. (5/64 in. — 3/16 in.) size has very good strength; consequently fine details can be given great strength by using this material instead of mortar as is often done, care being taken, however, in making and ramming the concrete.

Strengths in tension, to bending, and under shock. — The strengths in tension, to bending, and under shock which vary in the same direction, are of as great interest as the compression strength, when we consider the handling, transport, and putting into position the finished product has to undergo.

The results of Mr. Dutron's tests show that these strengths are better in the case of concrete made of broken stone than when round gravel is used. Concrete made with fine sand or dust gives strengths equal or better than those made with Rhine sand (coarse sand).

We think it reasonable to conclude that to get a concrete which, whilst having good strength in compression is also good as regards tension, bending, and shock, broken stone must be used; furthermore Rhine sand [0/5 mm. 0 — 3/16 inch)] size is desirable as it gives great strength in compression, although it can be partly replaced by fine sand without spoiling the strength in tension; this is done if the saving on the materials is appreciable.

Steel. — We use commercial mild steel bars : the minimum tensile strength is 37 kgr./mm² (23.5 Engl. tons per sq. inch) with 20 % elongation taken on ten times the diameter. Usually however we have used old signalling wire of semi hard steel 4 mm. (5/32 inch) in diameter often disposed of as scrap. This wire has to be

bundled and requires a certain amount of labour to straighten it : owing to its quality, however, a particularly stiff reinforcement can be provided even in the case of the smallest parts and these will not get out of shape even when being handled, nor whilst casting.

Off-loading and handling of raw materials.

The yard is laid out longitudinally : along one side there is a standard gauge siding and along the other a system of Decauville (1 ft. 11 5/8 in.) tracks with turntables and connections to the shops and stores. Up to the present the raw materials have been off-loaded by hand. The sand, gravel and broken stone are discharged in heaps alongside the siding in the yard so as to avoid any subsequent barrowing or loading into Decauville trucks. The two mixers in the yard work near the stacks of raw materials : they are moved along as required by the work. At a later date the handling of the raw materials as well as of the finished product will be done, at least in part, mechanically.

Manufacture and repair of the moulds.

Most of the moulds used at Roulers are made of wood. These forms deteriorate much more rapidly than those made of metal but cost much less. We estimate that the most delicate and the most used moulds, such as those for platform edges last four years before becoming too bad for further use. During the winter they are carefully overhauled as the wood absorbs moisture and in swelling becomes distorted; the parts come apart, deteriorate, and rot locally where they have been nailed together.

With a working staff of about one hundred men we keep five or six joiners permanently employed making and repairing forms.

These joiners work under a charge hand to whom the drawings of forms to be made or altered are given. The joiners' shop is equipped with a universal wood working machine and a band saw, motor driven; special work such as planing, champfering, etc., is done by machine.

The number of joiners required in a yard depends on the variety of parts to be made, and can be reduced when the parts have been standardised.

Parts of constant section are made in simple forms; the inside face of the wood forms are planed to facilitate stripping and improve the appearance of the parts; these are oiled if need be. To avoid having sharp corners, the angles are filled in with triangular strips.

In his general report on « Concrete parts produced in series » (question 7 of the 2nd Section of the Liége International Congress, September 1930) Mr. R. Dutron made the following remarks on our report to the same Congress :

> Moulding is usually done in wooden moulds supported on a table standing 60 cm. (1 ft. 11 5/8 in.) above the ground to facilitate the work. Although they can be used over a considerable period these wooden moulds require to be overhauled and repaired periodically. For the mass production of standard parts this method would not be economical nor can a really fine finish be obtained.

We also think that metal moulds are the ones to use for standard parts produced in large quantities, the moulds being either all-metall (cast iron or cast steel sections) or with a wooden framework covered with plate of suitable thick-

ness. The experience of years shows however that many alterations in dimensions of the parts to be made have often to be made before arriving at a « ne varietur » pattern. A wooden mould being more easily altered than a metal one, we felt it more prudent not to go in for the latter hastily, nor too soon, the more so as the first cost is greater. For rather complicated parts of limited use, wooden forms, when carefully made, can, if everything be taken into account, bear comparison with metal forms. As regards « fine finish », except for some fences and posts in stations, this is rather a matter of indifference in the utilitarian equipment of a railway.

Description of the moulds and of the parts manufactured.

Benches. — For straight parts such as posts, slabs, girders, etc., we have provided benches standing about 60 cm. (1 ft. 11 5/8 in.) above the ground; these benches are carried on concrete or wooden trestles, the tops not being fastened down; they can therefore be removed without being damaged when requiring repairs or during the winter. The wear is almost nil.

Concreting on benches is better than on the ground or on paving; if the latter is done the area has to be sanded or covered with paper which means poorly finished sides and also a reduction in output of the men.

Wooden benches cost no more than paving. The tables are oiled frequently and if a very smooth lower face of the part is wanted, the bench tops are planed or covered with thin sheet metal plates or asbestos boards.

Ordinary platform edgings. — The forms are set up to mould ten parts at a time. The Roulers yard is equipped to produce 150 parts a day or 30 000 a year.

The forms are opened at the end of three days in good weather; there are therefore 45 moulds each for 10 parts.

When concreting the forms are set up and well oiled by means of waste oil of low price, after which the reinforcement is put in place. This reinforcement consists of old 4-mm. (5/32 inch) semi hard steel signalling wire arranged in square mesh; this wire is not deformed when ramming the concrete. This reinforcement is placed very close to the inside face which is the face near the table but is always prevented from being level with it by the end hooks of the joint reinforcement and by its own rigidity.

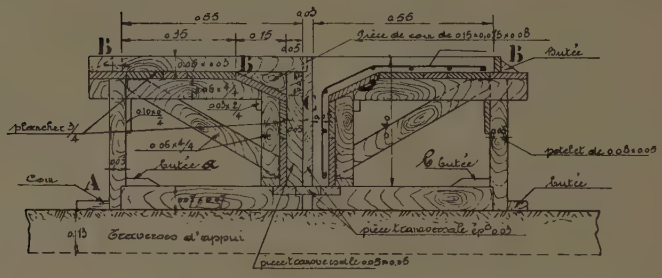
The concrete is mixed relatively dry, [2 to 3 cm. (3/4 inch to 1 3/16 inch) settlement of Abrams cone] and is well rammed until the liquid mortar appears on the upper horizontal surface; this surface is then smoothed off with a trowel. Ramming is done by hand; ramming by pneumatic tools or by jarring tables might be considered advantageously as the quality of the concrete is improved thereby. The forms designed in this way make it possible to smooth off the side of the object being made that will be seen, this face also being the upper one of the mould.

The concrete is usually allowed three days to harden; during this period care is taken in warm weather to wet it frequently and to shade it from the sun, as otherwise there is danger of too quick drying of the thin walls and of the concrete setting badly.

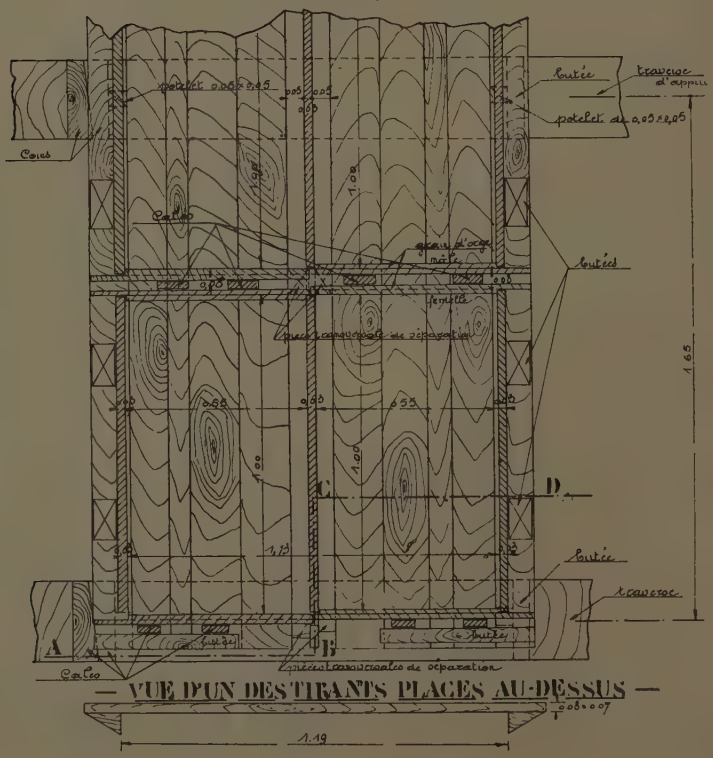
This could also be done if, when stripped from the forms, the parts were immersed in tanks until fully set : no such tanks are available at present, however.

Fig. 1. — Moulds for n

Elevation and section A-B-C-D.

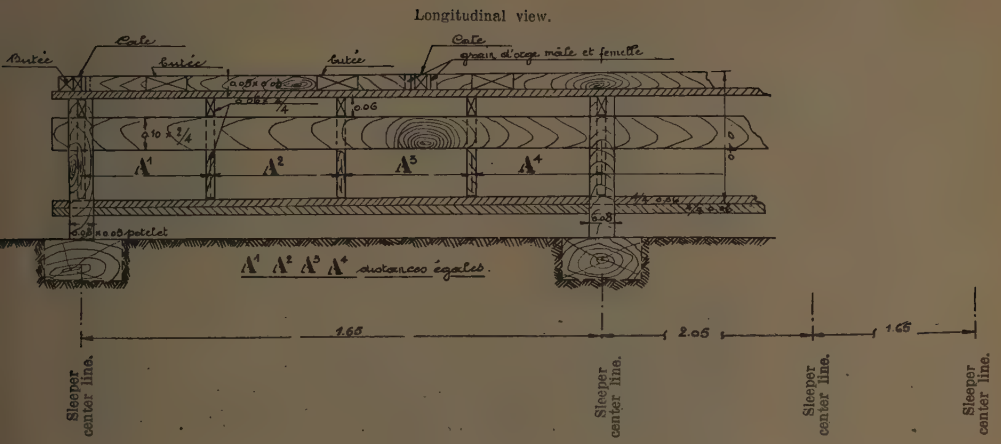


Plan.



— VUE D'UN DES TIRANTS PLACÉS AU-DESSUS —

dinary platform edge pieces.



Explanation of French terms:

Butée = Stop. — Cales = Wedges. — Distances égales = Equal distances apart. — Grain d'orge mâle (femelle) = Male (female) moulding piece. — Traverses d'appui = Sleeper supports. — Piece de coin = Wedge piece. — Pièces transversales = Cross pieces. — Pièces transversales de séparation = Division cross pieces. — Plancher = Boarding. — Potelet = Post. — Vue d'un des tirants placés au-dessus = View of one of the tie rods placed above.

At the end of three days the parts are removed from the moulds.

To do this the wedges A (fig. 1) are taken out and the piece *a* removed the full length of the cross pieces, the cross piece C is withdrawn as are the stops B, B′ and D; the workmen are careful to rap the mould properly to prevent any adhesion and then turn out the part onto a stretcher on which it is carried to the stacking yard. The cast piece is kept in stock about one month before it is sent to the place where it is to be used.

The cast parts are handled with the greatest care and as a result are not damaged.

The edgings are used to hold up the sides of passenger platforms in the Belgian National Railway Company's stations; they are gradually replacing the edgings made from timber, brick, or stone which in varying degrees were more costly in material, maintenance or placing and were not so good in appearance.

The Roulers yard has supplied so far about 80 000 of these parts which have been sent without appreciable damage to all parts of the country.

The forms have been in use for three years and so far not a single one has been withdrawn from service. The edging sections are about 1 m. (3 ft. 3 3/8 in.) long and weigh about 110 kgr. (242 lb.); each has a tenon and a mortise for assembling when being put into place or for separating them in the event of damage or of alteration to the platforms.

Edging of raised platforms. — The forms are much like those for ordinary

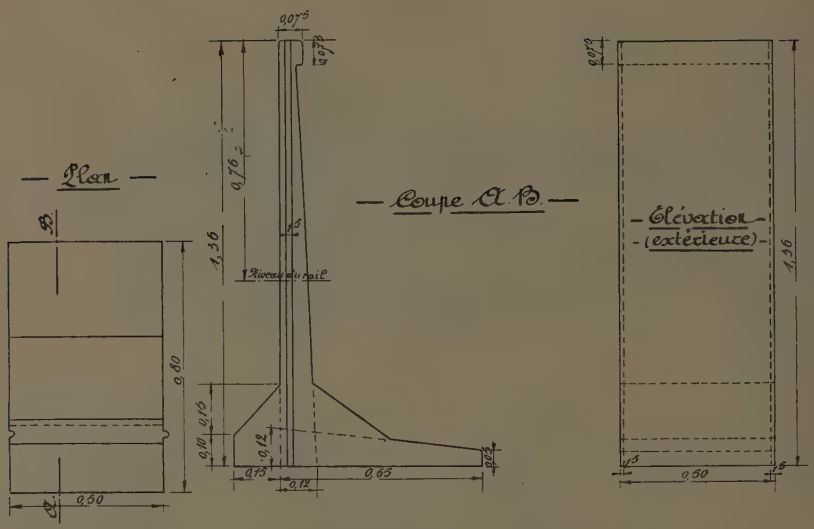


Fig. 2. — Edgings for raised platforms.

Explanation of French terms:

Coupe A. B. = Section through A. B. — Elévation (extérieure) = Elevation (exterior). — Niveau du rail = Rail level.

platform edging and the cast parts are stripped in the same way. These parts were first used in Belgium in 1930.

The details are only 0.50 m. (1 ft. 7 11/16 in.) long, so that they can be handled more easily. Each weighs 250 kgr. (550 lb.) (fig. 2).

Ordinary barbed-wire and expanded-metal fencing posts (fig. 7). — The posts are concreted upon a bench which acts as the lower face of the mould; the side walls carry the mouldings which form the recesses in the posts. The holes are made by cores which are withdrawn after pouring the concrete. There is room for five to six posts in the length of the bench. The reinforcement consists of four 4-mm. (5/32 inch) wires; when concreting short ends of 4 mm. wire are laid transversely about every 20 cm. (8 inches), these pieces acting as straps and preventing longitudinal cracking of the posts.

In rectangular or square section posts these straps are unnecessary except when putting the reinforcement into place.

We have made corner and end posts consisting of an upright with a strut, all cast in one piece for different types of fencing.

Posts for the « Charleroi » type fencing. — This fencing consists of concrete posts with wood lattice panels. These panels are bolted to steel flats embedded in the concrete.

The concrete posts are substituted for the oak posts formerly used, the price of the latter being higher, the life shorter

and the upkeep more costly. The wood lattice is made in large quantities at the Belgian National Railway Company's saw mill at Charleroi.

When in place the posts and horizontal laths are painted a light colour, light green for example, and with the vertical strips painted white the effect is very pleasing. There are two types of fencing differing in height.

The mould for the post has two separate stops nailed to the bench top : the half round irons are laid thereon and after concreting the form is stripped off without difficulty.

Fencing of this kind is not so cheap as the more decorative fencing made entirely of concrete, described below.

Post and lattice fence in concrete. — The post mould has wedges which make the grooves into which the panels fit.

Fig. 3. — Decorative fencing.

Special posts are made for fences to be built on slopes; the grooves are of different heights.

The panels, many varied designs of which can be imagined, are made up on the benches by means of slightly tapered blocks; pins on the blocks register with holes in the bench and the mould is stripped whilst the concrete is plastic; so that this can be done the blocks are fitted with eye bolts.

In order that the sides may be really smooth it is a good thing to concrete with cement mortar and if need be, use metal moulds. This open work fencing made of concrete throughout costs little, requires no maintenance, and is pleasing to the eye (fig. 3).

Kilometric and hectometric posts. — These posts are of the same dimensions as the cast iron or steel posts in use. Concrete has the advantage as regards cost price and lower maintenance (fig. 4).

Various slabs. — These are concreted on the benches : the mould consists of frames held together by drifts and wedges : the reinforcement consists of bars of steel laid crosswise and put in place by the concreter himself (fig. 5).

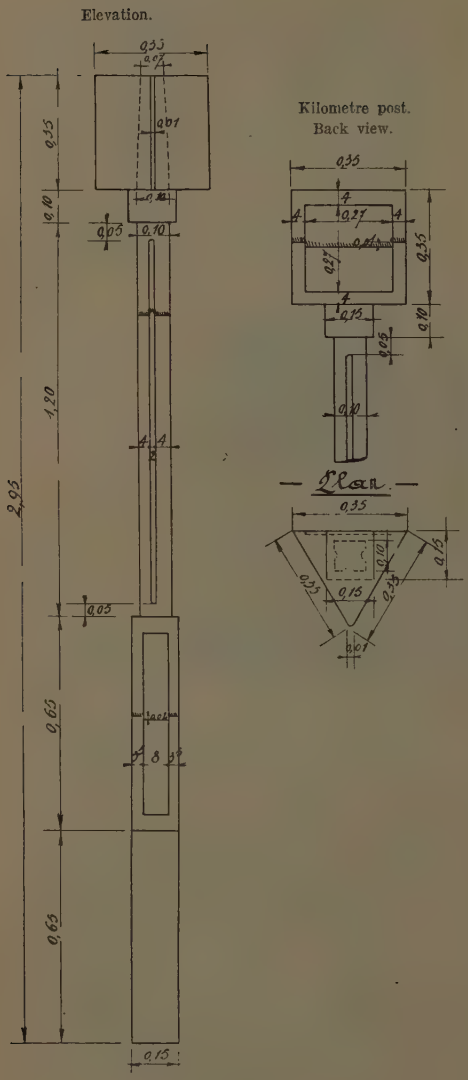


Fig. 4.

Fig. 5. — Miscellaneous slabs.

Channels. — These are used to cover heating and signalling mains.

There are three widths : 0.30 m. (11 13/16 inches), 0.50 m. (1 ft. 7 11/16 in.) and 0.90 m. (2 ft. 11 1/2 in.). Some of these channels are fitted with iron bars for attaching signal wire guide pulleys. The mould is easy to follow: it consists of interior and exterior wall held in place by a series of wedges which have to be removed before stripping. The interior is open in the middle : when the concrete is not too liquid there is no tendency for the concrete to rise in this opening when ramming. The moulds are made for the manufacture of a series of ten channels; the wooden sides are in one piece; reinforcement : cross laid 4-mm. (5/32 inch) bars every 10 cm. (4 inches) (fig. 6).

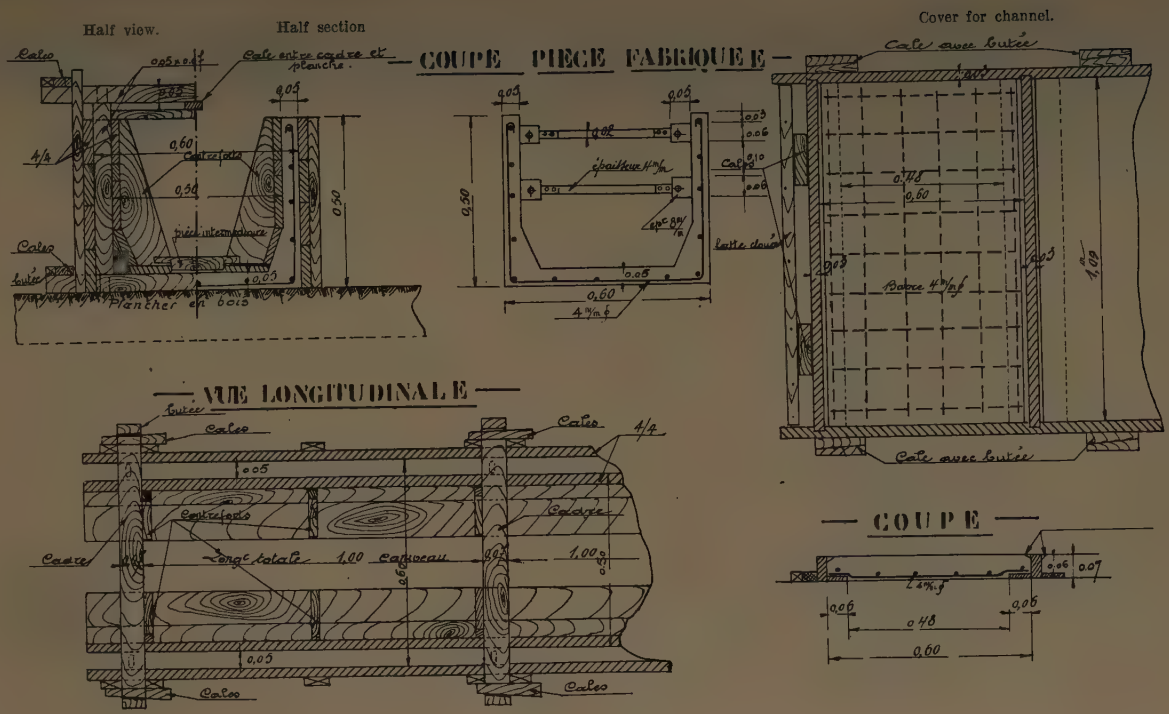


Fig. 6. — Channels.

Explanation of French terms:

Butée = Stop. — Cadre = Frame. — Cale entre cadre et planche = Wedge between frame and planking. — Cales = Wedges. — Contreforts = Stays. — Coupe = Section. — Epaisseur = Thickness. — Latte clouée = Nailed lath. — Longueur totale caniveau = Total length of channel. — Pièce intermédiaire = Intermediate piece.

Special pipes. — These pipes of a reinforced pattern are used as culverts under the lines; the sections manufactured are 0.80 m. (2 ft. 7 1/2 in.), 1.20 m. (3 ft. 11 in.) and 2 m. (6 ft. 6 3/4 in.) in diameter. Metal moulds are purchasable for the pipes of the usual diameters and thicknesses but such pipes are not strong enough for use under our lines. Our moulds are built up from mild steel plate stiffened by wooden ribs. The two walls are kept at their correct distance apart by means of wedges and tie bolts; the steel plates form half cylinders which overlap at the joints. Metal moulds would be stronger but would cost more.

Flower vases. — The very thin walls and fine finish needed make it necessary to concrete with cement mortar. The forms consist of side walls on which are carried plate moulds.

Concreting is done on a bench. The front of the vase is decorated. The bottom has several holes through it. We have made three patterns, 0.40 m. (1 ft. 3 3/4 in.), 0.70 m. (2 ft. 3 1/2 in.) and 1 m. (3 ft. 3 3/8 in.) long.

Curve checking posts. — The posts are used when checking over railway curves laid in by means of parabolic transitions, a coach screw in the top locates the position of the track in plan and level.

The mould is in two parts which open on the diametrical plane; when concreting these two parts are held very tightly in place by a wooden frame. The reinforcement of the base is introduced during the concreting through holes in the walls and the longitudinal reinforcement through the top : the mould can be stripped quite easily only one day after concreting owing to the taper of the piece.

White sign bords for caution signals (figs. 7 and 8). — Five white sign boards with from one to five black bars are placed 50 m. (164 feet) apart before every caution signal in Belgium.

Up to the present these boards made of wood are set at an angle to the line and are carried on three wooden uprights. The white vertical board in concrete we have made as an experiment is in one piece and is, we think, an improvement as regards cost, appearance and maintenance.

The form, built up on the bench, is simple to follow.

Foundations for various signalling apparatus. — Many railways make the foundations carrying signalling equipment from new or recovered wood. In some cases ordinary concrete without any reinforcement is used, the concreting being done on the site. The use of wood is as little logical as it would be to make the foundation of a building or a pylon in wood, seeing that to do so is to use the least durable material in the most exposed position.

We may add that wood even if recovered is relatively dear and that the cost of foundations often exceeds the cost of the apparatus itself. The reason which appears to have prevented the systematic use of concrete is the great variety of signalling appliances.

After many trials we have succeeded in making foundations in both plain and reinforced concrete, manufactured in the yard, which we have reduced to ten patterns, suitable for use with all appliances on the Belgian National Railway Company.

The use of concrete weighing 2 200 kgr. to 2 300 kgr. per m^3 (3 700 to 3 875 lb. per cubic yard) gives very durable and cheap foundations requiring little maintenance and having a long life.

Fig. 7. — White sign board for caution signal, gradient post, and fencing with concrete posts.

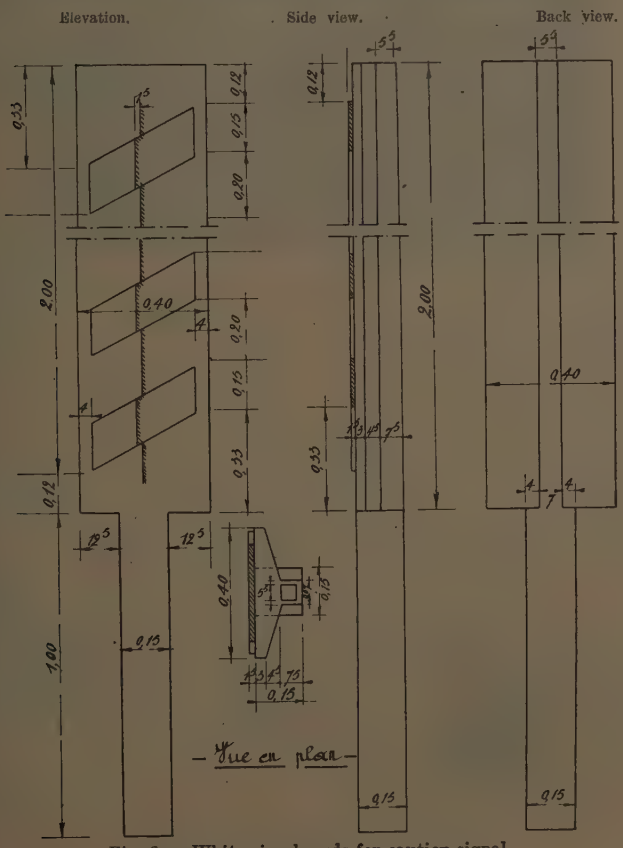


Fig. 8. — White sign boards for caution signal.

These boards are used with 1, 2, 3, 4 and 5 bars.

Each pattern can be used for several appliances and with this object the foundation consists of a concrete frame, the top plate having the necessary holes for the holding down bolts of the appliances (figs. 9 and 10).

It will be readily understood that a sufficiently large number of holes suitably positioned can be made in this top plate so that several different types of appliances can be secured to it.

The top face of the foundation is arranged to come slightly above the level of the ground so that the holding down bolts can be inspected and the nuts tightened up at any time. The lower plate forms the base of the foundation; it is buried in the ground to a depth of

Fig. 9. — Wire compensator on concrete foundation.

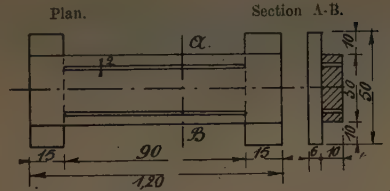
0.40 to 0.50 m. (1 ft. 3 in. to 1 ft. 7 in.); if the resistance to displacement in the ground so given is insufficient, the base is enlarged or vertical ribs acting as stops are provided.

The signalling appliances differ from one railway to another; there is no doubt, however, that the standard patterns of foundations we have got out can be adopted with advantage everywhere by making provision for bolting down the appliances.

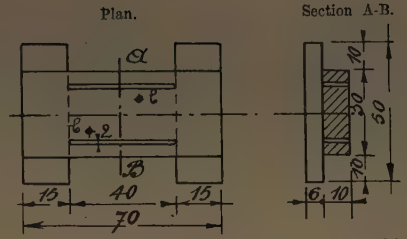
The foundations so far tried experimentally by the Belgian National Railway Company have been used for the following equipment :

Ground signals;
Signals indicating the position of points;
Cesar slots;
Vertical and horizontal pulleys and multiple pulley frames;
Simple and multiple rod guide pulleys;
Compensators for wires;
Compensators for rodding;
Stroke reducing levers;
Various distribution boxes;
Relay covers, etc.

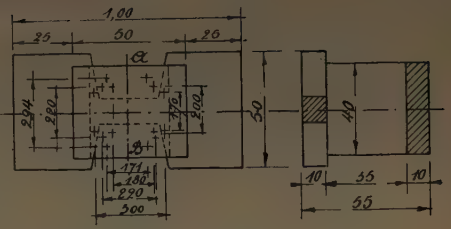
As an example, a drawing of some foundations is given : these parts are rather strongly reinforced by 10-mm. (3/8 inch) bars. The forms are easily followed; they are so arranged that a series of ten pieces can be made at a time as in the case of



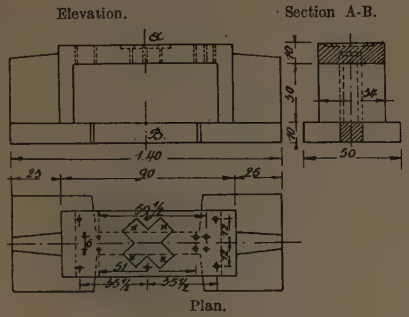
Foundation for rodding guide pulley (6 to 10 rods).



Foundation for rodding guide pulley (1 to 5 rods).
Foundation for rodding guide pulley (1 rod).

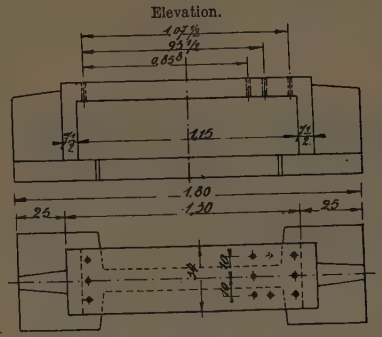


Foundation for :
1. Travel reducing levers (171/294) ;
2. Point position indicator (220/230) ;
3. Red Cesar slot (200/230) ;
4. Relay case (180/200).



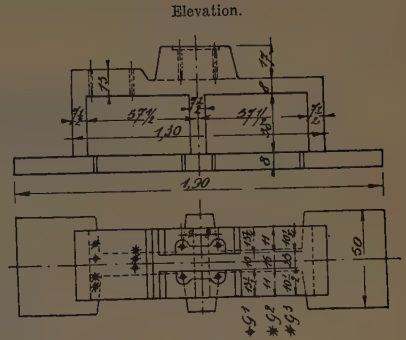
Plan.

Foundation for :
1. Single or double crank.
2. Single stage horizontal frame with 2 pulleys (0.51 × 0.06) ;
3. Double stage horizontal frame with 4 pulleys (0.59 1/2 × 0.06) ;
4. Ground signals (35 1/2 × 35 1/2 × 24) ;
5. Crank with offset arm (2 cranks) ;
6. Crank with offset arm (3 cranks).



Plan.

Foundation for :
1. Double stage horizontal frame with 8 pulleys (1.07 1/2 × 10/10) ;
2. Four-stage horizontal frame with 8 pulleys (0.93 1/2 × 20) ;
3. Four-stage horizontal frame with 12 pulleys (0.858 × 10/10) ;
4. Crank with offset arm (4 cranks) ;
6. Crank with offset arm (5 cranks).



Plan.

Foundation for :
1. Compensator (1 rod G [1]) ;
2. Compensator (2 rods G [2]) ;
3. Compensator (3 rods G [3]).

Fig. 10. — Foundations for signal appliances.

the channels, a drawing of which is given.

The many types of foundations for safety appliances have been reduced to a few standard patterns suitable for rodding and wire transmission as well as for the compensating devices.

The small posts supporting the wire

Fig. 11. — Grooved posts with enlarged base.

pulleys can also be made entirely in reinforced concrete or can be made up of a short piece of rolled section, sheared to the size, the lower part embedded in concrete, with the base enlarged to make them more stable.

Coal stacks, scrap bins, loading ramps, tanks (figs. 11, 12 and 13). — The lack of room and the neat appearance of the installation frequently justify the use of rather high enclosures [0.80 m. to 2 m. (2 ft. 7 1/2 in. to 6 ft. 6 3/4 in.)] for stacking coal, dumping scrap, storing sand, etc. The arrangement, modification and extension of stations and works very often require the removal of these various stores after a short period. An easily moveable and at the same time strong enclosure is therefore required, and we have made quite a number, built up from grooved posts with large bases, and panels. If damaged any number of these parts can be replaced with ease.

The same standard sets of posts and panels can be used to form small bins for scrap in isolated corners of the station; for the sides of shunting humps; for cheap shelters; pits for weighing machines, turntables, etc. Properly studied standardisation will reduce the number of the different parts (posts and slabs) to a minimum.

Making up the reinforcement.

The wire is cut to length by an improved shears; templates automatically give the length wanted.

The cut lengths are then put on to a gauge and fitted with hooks : special benches are used on which the reinforcement is finished off. Many of the reinforcements used being made up with old signalling wire, of semi hard steel, bundled after cutting, it is necessary to straighten them by means of pneumatic or electric hammers. The hooks are formed on the rods by a specially designed bending press for small hard steel rod. These reinforcements cannot be knocked out of shape during tamping and are very cheap.

The rigidity of the reinforcement makes it possible to reduce to a minimum binding — by thin annealed iron wire — the bars where they cross one another.

The reinforcements, when completed, are stacked by types in different bins so

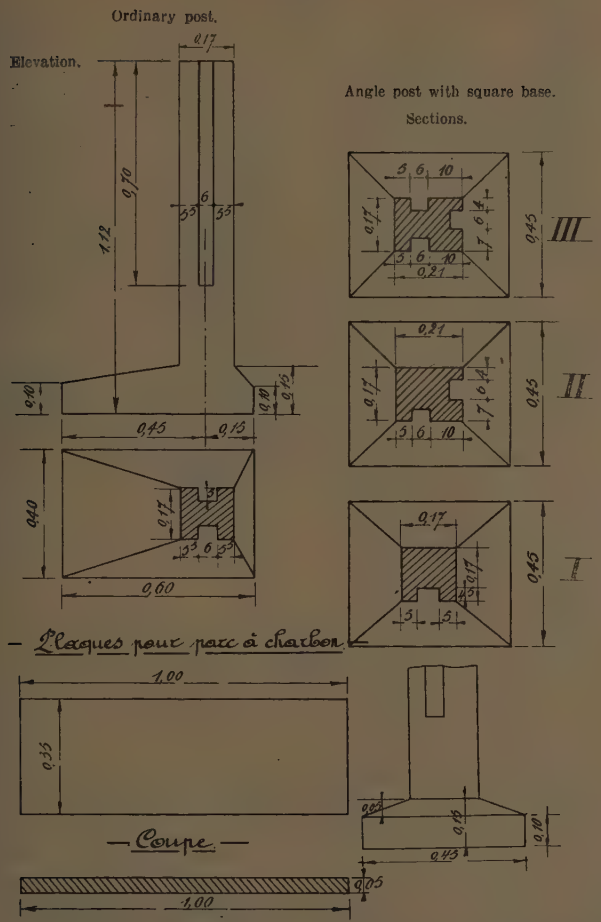


Fig. 12. — Posts and slabs for coal stacks or scrap bins.

that the stock can be checked easily. The labour used making the reinforcements is booked up and brought to account when getting out the cost prices of the parts; this also helps to check the output which varies between unity and the double according as the labour is skilled or not.

Each morning the charge hands draw from stock the reinforcement needed during the day.

Manufacture, transport and use of the concrete.

The yard has two mechanical concrete mixers. One of them has a capacity of

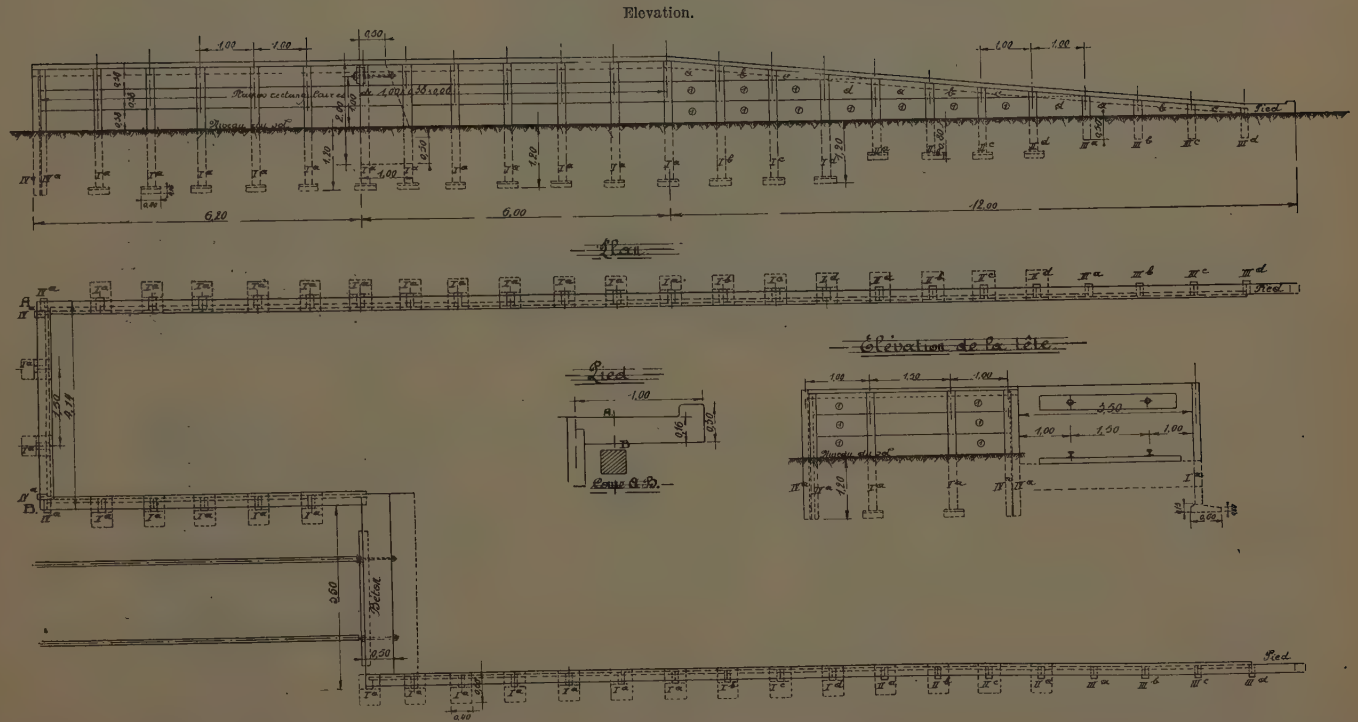


Fig. 13. — Loading ramp, small pattern.

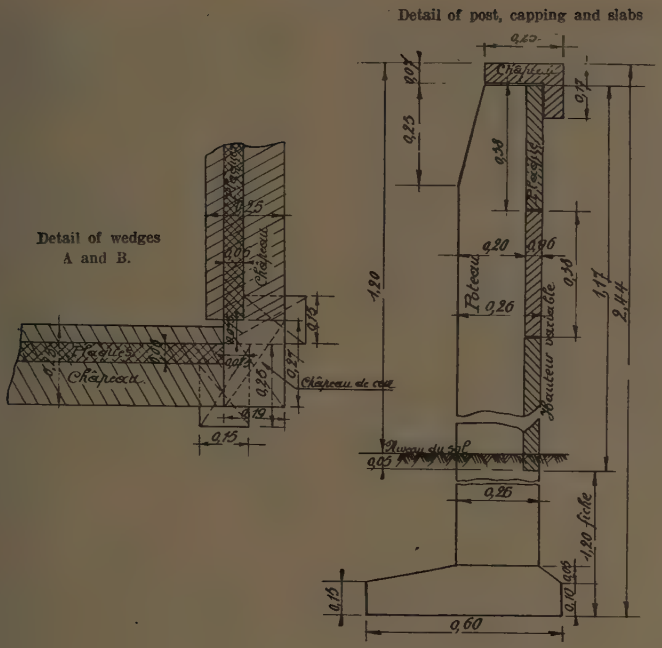


Fig. 13 (continued). — Loading ramp, small pattern.

Explantation of French terms:

Chapeau = Capping. — Chapeau de coin = Corner capping. — Détail des coins A et B = Detail of wedges A and B. — Elévation de la tête = Elevation at raised end. — Fiche = Depth driven. — Hauteur variable = Variable height. — Niveau du sol = Ground level. — Pied = Foot of ramp. — Plaques rectangulaires = Rectangular slabs

150 l. (5.3 cubic feet) is mounted on wheels, with an automatic elevator and loader and a water reservoir which automatically empties into the mixer. It is driven by a 3-H. P. Lister petrol engine. It can also be coupled directly to a 220-volt d. c. electric motor instead of the petrol engine. This mixer can give 3 to 4 m³ (3.9 to 5.2 cubic yards) of mixed-concrete hourly when working under good conditions. The bottom of the mixing chamber arranged as a helix gives an up and down movement to the mass to be mixed at the same time as the latter is churned up by the blades. The chamber turns slowly (16 r. p. m.) on a pivot having a double ball bearing. The wheels have wide steel tyres so that the mixer can be moved easily.

The second machine has a capacity of 350 l. (12.4 cubic feet) of materials before-mixing, has a conical tipping chamber, automatically tipping water reservoir, mechanical loader with automatic trip; 6-H. P. motor; output of 10 to 12 m³ (13 to 15.7 cubic yards) an hour.

The mixing chamber revolves and tips and has vanes and paddles in series so that the mixture is turned over four times per revolution. The speed is 19 r. p. m.; it can also be driven by electric motor. The elevator bucket, made of steel plate is controlled by a single lever and is hinged in such a way as to give it ample inclination so as to assure it empties completely and instantaneously. The water is obtained from a tank which automatically discharges the desired quantity. The complete machine weighs 2 000 kgr. (4 400 lb.).

The two mixers stand near the dumps of raw materials; the time for mixing is two minutes; the new concrete is tested at frequent intervals by the Abrams cone (slump test) to get an idea of its fluidity and from time to time 20 × 20 cm. (8 in. × 8 in.) test cubes are taken for more complete tests. The concrete is transported in Decauville trucks to the place where it is to be used; it is emptied into tubs from which it is taken as needed, and the concreting is done by filling the forms gradually and ramming.

The mixers and the dumps of sand and stone are close to the cement stores; the places at which concreting is done are so selected that the bulkiest pieces are made nearest one of the mixers so as to reduce the distance they have to be carried.

Stripping, storing and loading.

In good weather, after drying for three days, the parts are carefully moved and stored near the loading siding. Each part is marked with the date made so as to fix the date by which it can be sent away. This is not done under one month for parts made of ordinary cement (P. A. N.) and under fifteen days when supercement (P. A. D. R.) is used.

Certain parts when damaged or broken in being taken out of the moulds are touched up by a skilled workman who also removes the fins and gives a good finish to the piece; this is all done easily as the concrete is only just beginning to set.

Loading up is done as far as possible by special gangs, which prevents the workmen from being taken off the usual jobs. Most of the parts weigh more than 100 kgr. (220 lb.) and require three men for handling them. We think a 500 to 1 000-kgr. (1 100 to 2 200 lb.) motor crane would be very valuable and the savings to be made would pay off the cost in a short time as the cost of labour for loading amounts to 1/10th of the total labour costs. We have also under consideration the installation of a cheap overhead monorail transporter, and also of roller sections.

Accountancy.

In a yard, one of the most difficult and at the same time most important things to be done is to set up an accurate accountancy system. When aided by a good technical organisation it helps to get the best output. It makes it possible by various annotations to obtain an idea of the relative importance of the operations. The accountancy at Roulers yard is based on the system of constant stock taking.

The manufacture from this aspect is divided into three phases :

1. Making the reinforcements.
2. Mixing and carrying the concrete.
3. Making the parts.

When making up the reinforcements, the weekly production programmes are kept up to date. These programmes show the materials used daily, the working hours and the daily production.

They make it possible to control the

movement from stores to the yard (issue ledgers), manufacturing operation (yard operation journal) and the movement from the yard to the stores (receipts ledgers).

The charge hand over the section making the reinforcements is responsible for checking the materials and hours of work; the accountancy work is done in the yard office.

Materials are drawn from stores on an issue note and the finished material is returned to stores weekly.

The movement as regards quantity is kept up to date in the stores on stock cards.

The same procedure is followed when mixing the concrete and when manufacturing parts.

The checking of materials used for making concrete is done at the mixer solely, by noting the quantity of cement used seeing that the quantities of the other materials used depend upon the cement used as the mixtures have to be followed rigorously.

The total quantity of concrete is accounted for at the end of the day at the different points of manufacture and this is done by simple rule of three; the volume of each object made is known and also the number of parts made during the day; this shows to what extent the parts made affect the quantity of concrete used.

When getting out the costs of the finished parts we add a certain proportion of general charges distributed in proportion to the weight of the parts, as charges for handling and other overheads depend especially on the volume of concrete. A statement is available and shows the materials and wages included in the overheads so that their reative values can be ascertained.

The percentage of overhead charges added to the cost of the parts manufactured is fixed for each month; each month it is diminished or increased as needed. At the end of the year, the estimated general charges added should equal the actual figures or only differ by the value of the forms, an inventory of whose value is kept.

The manufactured parts are sent away with an invoice after being entered into the issue ledger.

We give below a list of the items included in the general charges; these are most important and may amount to 30 to 40 % of the total labour costs.

Classification of general charges.

01 — Administration (salaries of officials).
03 — Supervision (wages).
031 — Upkeep of plant and tools (wages and materials).
032 — Water, petrol, oil, used for the mixer motor.
033 — Smithy coal (materials).
034 — Tests (wages and materials).
035 — Costs of analyses and tests as invoiced.
04 — Handling materials received (wages).
041 — Loading up finished materials (wages).
042 — Cleaning up yard (wages).
05 — Lighting and heating.
06 — Losses, damage, and discrepancies in stores (materials).
07 — Time lost through bad weather (wages).
08 — Miscellaneous charges (wages and materials).
09 — Adjustments.
00 — Distribution of general charges.

625.13 (.42)

Cementation in the Severn Tunnel,

Great Western Railway (Great Britain) [1],

by R. CARPMAEL, M. Inst. C. E., M. I. Mech. E., Chief Engineer, Great Western Railway.

(*The Railway Engineer.*)

As is well known, the Severn Tunnel is one of the most important of the links of the Great Western Railway chain of communications. Failure to maintain communications between South Wales and London and the West of England via the tunnel entails a reversion to the old route via Gloucester, with an additional mileage of 25 miles.

During the first three months of each year the Engineering Department has « absolute » possession of the tunnel between the hours of 6 a. m. and 5 p. m. for the purpose of relaying, a work necessitating occupation of both tracks. During these occupations of the tunnel various repairs — for example, cutting out and replacement of defective brickwork — are also taken in hand, and for many years the tunnel generally was in such a condition that no further repairs were necessary.

Although the Severn Tunnel is the only subaqueous tunnel on the Great Western Railway system, there are many tunnels penetrating water-bearing strata, through the interstices of which water, particularly in times of heavy and continuous rainfall, makes its way through any defective joints in the brickwork lining. In such cases, unless of sufficient consequence to merit special treatment, this

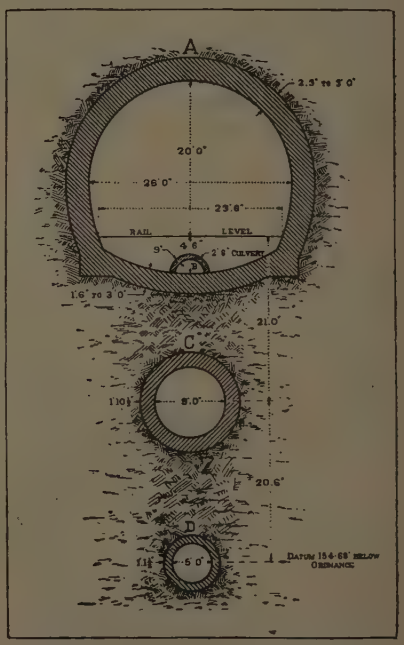


Fig. 1. — Section through Severn tunnel, showing also ventilating and drainage culverts.

percolation of water is collected and led into drains or ditches in the tunnels and thence carried away.

By comparison with certain of these tunnels, the Severn Tunnel, with the ex-

(1) Illustrations by courtesy of the *Great Western Railway Magazine.*

ception of a length of about one mile from the Bristol mouth, can fairly be described as a dry tunnel.

In 1924 some considerable trouble was experienced owing to excessive leakage into the tunnel of water from the River Severn at a point some 51 chains from the Bristol mouth owing to development of a « pipe » or open joint in the marl overlying the tunnel. The mouth of this pipe being in a portion of the river bed accessible at low water, it was found possible to seal the cavity with concrete poured in from the ground level. Similar trouble occurred in 1929, and remedial steps followed the same lines.

From a study of the history of the construction of the Severn Tunnel, a wonderful record written by Mr. T. A. Walker, the responsible contractor, of a successful struggle against heavy odds, it was ascertained that similar inrushes of water took place during the construction of the tunnel. The first of these was in 1879, when the heading, which was being driven by the Great Western Railway before the contract was let, broke through marl into gravel near 11 miles 12 chains (about 12 chains from the Bristol mouth) and a great run of gravel and water into the workings ensued. In 1882 the contract works were interrupted by a fall of marl and a subsequent inrush of gravel and water near the Sea Wall Shaft (11 miles 30 chains). Mr. Walker stopped this inrush, filling the hole from the ground surface of the river bed in the manner followed in 1924 and 1929. At the same time, ground subsidence, involving that of a brick chimney, also occurred close to the eastern bank of the river. This brick chimney was built between two wooden houses, in which lived with their wives and families men of the construction staff; in the middle of the night the chimney subsided right down into the tunnel heading, without, however, involving either of the houses, of which the occupants, who were all asleep at the time, escaped injury.

The very careful and accurate geological records kept by Mr. Walker of the strata through which the tunnel passes, considered in relationship to the recurrence of infiltration of water, all tend to prove the existence of open joints and of broken and faulty strata above the tunnel, particularly between 11 miles 10 chains and 11 miles 70 chains, and it was felt that special measures should be taken not only to strengthen the brickwork lining of this length of the tunnel, but to fill up any voids that might exist between the back of the lining and the surrounding strata, and to consolidate as far as reasonably possible the ground between the tunnel and the river bed.

It should here be emphasised that the original designers of the tunnel, with their somewhat limited knowledge of such works and with their lack of suitable equipment, had ever before them the risk of breaks through of river water (in fact, during construction the designed gradients were steepened to give increased cover). Apart from the minor mishaps mentioned, this risk did not materialise, and the real trouble was mainly due to the tapping on 18 October 1879, of a subterranean stream, known as the « Big Spring », on the Welsh side. The enormous quantities of water from this spring are adequately dealt with by means of pumps, and no further reference to it will be made.

It was apparent from the first that, to carry out the contemplated strengthening works, one method only was available, that is to say, by forcing liquid cement into and through the brickwork under a pressure sufficient to counteract that due to the maximum head of water at times of high tide. Treatment of defective structures by this method had previously been undertaken by the Great Western Railway, but on a comparatively small scale, and, for a work of the magnitude of that contemplated, it was considered advisable to enlist the services of

a firm of proved experience of this class of work.

The whole length with which it was proposed to deal was that from the Bristol mouth at 11 miles 0 chain to point 12 miles 5 chains where the geological

Fig. 2. — Drilling holes for grouting.

section indicated the termination of the gravel and marl and the commencement of a bed of sandstone and pennant rock; and of this length it was thought advisable to take in hand, as a first step, the half-mile length between 11 miles 30 chains and 11 miles 70 chains, for the treatment of which a contract was let in October 1929, to The François Cementation Company, of Bentley Works, Doncaster. Before commencing the work careful consideration had to be given to determine the method by which it could be carried out with the least interference with traffic.

During the first three months of the year operations of all kinds could have been carried out under the Engineering Department usual Sunday occupation, but as the time so available would have been insufficient, it was primarily necessary to arrange with the Traffic Department to extend this period by the inclusion of two months prior to the New Year.

The next consideration was the location of the machinery for compression of air for operating the drills, and for the mixing of the liquid cement and for pumping it through the drilled holes into the voids at the back of the brickwork and into the detective joints of the arch ring. It was decided to locate all this necessary machinery in sheds to be erected at the Sea Wall pumping station, where the necessary steam supply could be obtained from the Company's existing pumping plant and from whence the compressed air and grouting mains could be led down the ventilating shaft. These mains were carried into the tunnel throughout the whole length to be treated, and to them, at appropriate intervals, were fixed valves and connections for flexible pipes to be connected directly to the portable drills and to screwed pipes fitted into the drilled holes for the injection of cement grout. To form supports for the drilling of the upper holes there were provided travelling stages, erected with a minimum clearance of 12 inches outside the loading-gauge, from which drilling could proceed without interruption. These stages did not, however, prove to be successful, and for them were substituted stages mounted on trolleys running on the tracks, which, on this account, could be used only during the « absolute » Sunday occupations.

As an essential feature of the work

was that the running lines should, except during these operations, be kept absolutely clear, all plant which could not be kept clear during the week had to be brought into and taken out of the tunnel during Sunday occupations. Some of this plant was erected on trucks stored during the week on the Sea Wall sidings and some was lowered into and hauled out of the tunnel through the Sea Wall shaft, the latter method of transit being that wholly adopted throughout the latter stages of the work.

The expedite the work, it was carried out continuously throughout the 24 hours of each day.

The general programme was to drill a series of holes at intervals throughout the whole length to be treated. The holes through the invert were drilled during the week, and were bored to a total maximum length of 10 feet each, reaching

Fig. 3. — Air compressors and other plant for cementation work.

points from four to six feet below the lowest level of the invert. The remaining holes in the arch ring, which varies in thickness from 3 feet to 3 feet 6 inches, were drilled to lengths varying from 3 feet 6 inches to 5 feet according to the nature of the ground encountered behind the brickwork. The diameter of the holes through the ring was 3 1/8 inches, reducing to 1 7/8 inches in the surrounding ground. The injection pipes (1 1/2 inches dia.) passed right through the holes in the brickwork and were caulked from the extrados inwards to prevent possible damage to the brickwork by the development of undue pressure before the surrounding strata were consolidated. This method ensured that all cement injections commenced at the back of the brickwork, resulting in a final consolidation of the bonding of the latter. Injections of cement commmenced through the invert holes and were gradually followed upwards round the arch ring, injections through the crown being those last undertaken. A very considerable amount

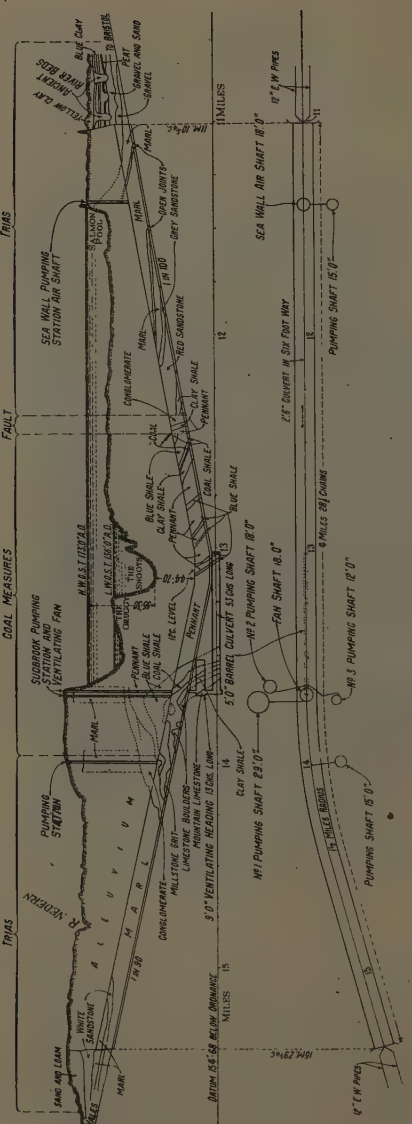


Fig. 4. — Sectional elevation of Severn Tunnel.

of water was tapped during the drilling, and injections were mainly carried out at pressures exceeding, by a determined amount limited to 25 lb. per sq. inch, the pressure due to static head of water above the tunnel. In the earlier stages of the work a tonnage limit of injection per hole was fixed, but during the later stages this was dispensed with and the maximum injection pressure was increased to 100 lb. per sq. inch.

The strength of the injection mixture varied with the pressure at the pumps necessary to force the cement grout against the head of water encountered. When pressures were low the richest mixture, 8 cwt. of cement to 80 gallons of water, was used, decreasing in strength to 1 cwt. in the same quantity of water as pressure increased.

The work in the tunnel commenced on 3 November 1929, and, owing to traffic requirements, terminated on 13 April 1930, during which period the amount of work carried out on the length 11 miles 30 chains to 11 miles 70 chains was as follows :

Number of holes drilled, 2 123, with a total footage of 9 503 feet.

Number of holes injected, 1 830.

Cement injected, 3 016 tons, averaging 1.16 tons per linear foot of tunnel.

The work carried out proved to be so successful that it was decided to extend operations to cover the whole length from the Bristol mouth, 11 miles 0 chain, to a point at about 12 miles 5 chains were the marl joined the sandstone rock. It was considered that this would form a permanent barrier against water travel along the top of the tunnel, and a further contract was entered into with the François Cementation Company, which work was commenced on 2 November 1930.

The work on this contract followed generally the lines of that previously carried out, with certain modifications of procedure, spacing of holes, etc., resulting from experience gained during the

previous work. The total work in the tunnel under the two contracts amounted to :

Number of holes drilled, 4 233, with a total footage of 21 683 linear feet.

Cement injected, 8 132 tons, averaging 1.48 tons per linear foot of tunnel.

In addition to the work in the tunnel proper, similar strengthening by cement injection through drilled holes was carried out on the Sea Wall and Sudbrook ventilating shafts. No difficulty was experienced at Sea Wall, but at Sudbrook it was found necessary to inject and fill numerous voids surrounding the tunnel at the base of the shaft, and extending to the 9-foot ventilating heading and the 5-foot barrel culvert below the tunnel. Owing to these extensive voids, due to the broken nature of the ground traversed and to difficulties experienced during construction, the travel of injected cement along the tunnel was very considerable. All injections were carried out through the walls of the shaft itself, and definite indications of cement travel were given by its appearance through the brickwork joints of the heading and culvert and of the tunnel itself at an extreme distance of half a mile from the shaft.

The actual amount of work carried out on the two shafts is as follows :

Sea Wall.

Number of holes drilled, 17, with a total footage of 68 feet.

Cement injected, 91 tons.

Sudbrook.

Number of holes drilled, 85, with a total footage of 377 feet.

Cement injected, 455 tons.

The whole of the injection work was finished on 3 May 1931, and the plant subsequently removed.

Owing to the working conditions, the greatest care was necessary to safeguard traffic and the staff working in the tunnel; it is satisfactory to know that the whole of the work was carried out in a very methodical manner without accident, a result which reflects great credit on all concerned.

[621 .132.3 (.73)]

New Pacific type locomotives, Pennsylvania Railroad,

by E. C. POULTNEY.

(*The Railway Engineer.*)

The express passenger locomotives which form the main subject of this article have been designed and built at the Juniata shops of the Pennsylvania Railroad, Altoona, Pa., to meet the requirements of Mr. F. W. Hankins, Chief of Motive Power.

The locomotives, which are designated Class K5, follow closely in design, and also in appearance, the well-known K4.s. engine previously introduced by the late Mr. J. T. Wallis, formerly Chief of Motive Power, and more recently Assistant Vice-President in charge of operation, and which were first built at Altoona in 1914.

Before dealing with the latest 4-6-2 type locomotives, it is intended to refer briefly to the development of the Pacific

express locomotive for heavy passenger train operation on the Pennsylvania system, and table I shows for comparison the leading dimensions of the principal classes in the order of their appearance.

Pacific type engines.

The need for larger and more powerful locomotives to handle the main-line fast passenger services first became apparent in 1906, at which time the work was being done exclusively by Atlantic type engines, the use of which necessitated the double heading of the more important and heavier trains. To provide for the increase in tractive effort, the use of six coupled wheels became a necessity, while the greater boiler capacity required, more especially important because at that period the superheater had not become established in American practice, suggested the adoption of the 4-6-2 wheel formation.

The first Pacific was built experimentally for the Pennsylvania by the American Locomotive Co., at the Pittsburgh Works, and placed in passenger service on the Lines West for traffic between Pittsburgh and Chicago in 1907. This engine was at that time the heaviest Pacific, and of about the maximum power for the type employing saturated steam, and in comparison with the Atlantics then in service, constituted a considerable advance in power.

The success attained by the new engine prompted the building of the type at Altoona, and the first appeared in 1911. These locomotives were similar to the experimental design, but incorporated certain modifications, the principal of which was the inclusion of the Belpaire firebox, in conformity with Pennsylvania standards, in place of the round top radially stayed type used for the first engine.

These new locomotives, known as Class K2, used saturated steam, but were subsequently re-designed and fitted with type A superheating equipment, and, as thus modified, became class K2.s.a.

In 1913 a further class was added, known as K3.s., having larger cylinders, superheaters, and mechanical stokers.

In order to consider the next step in the development of the Pacific locomotive, it will be necessary to refer to the Atlantic type, the further employment of which received attention in 1910, when a new 4-4-2 was built at Altoona. The locomotive used saturated steam, and in respect to cylinders, driving wheels, and steam pressures, the dimensions were as for the previous engines, but the boiler was much larger, with a total heating surface of 3 582 square feet, and a grate area of 55.1 square feet. The engine weight was 103 tons, of which the coupled axles carried 59.5 tons, or nearly 30 tons each.

The success of this design, not only on the plant, but also in service, led to a further two similar locomotives being built. These were, however, superheated, and, as thus fitted, became class E6.s. After certain other trials, and the making of some changes to the new and original engines, a further large Atlantic design was commenced at Altoona in 1913, embracing modifications suggested as a result of experiences with the first three locomotives. The new engine became the latest and final E6.s. class.

These locomotives — in many respects remarkable — included in their construction certain features of importance. The cylinders were 23 ½ by 26 inches, which, with 80-inch drivers and the standard working pressure of 205 lb., provided the high tractive effort of 31 275 lb., made possible because of the considerable axle loading permitted. The adhesive weight was 60.7 tons, or over 30 tons per axle. With such a weight and two cylinders only, special care was taken to avoid increased rail loading, due to the hammer blow. This dictated special steel for the motion, which was of light design for the elimination of weight, and hollow piston rods

Class "K 5" 4-6-2 express passenger locomotive.

Fig. 1. — General view.

Fig. 2. — Boiler.

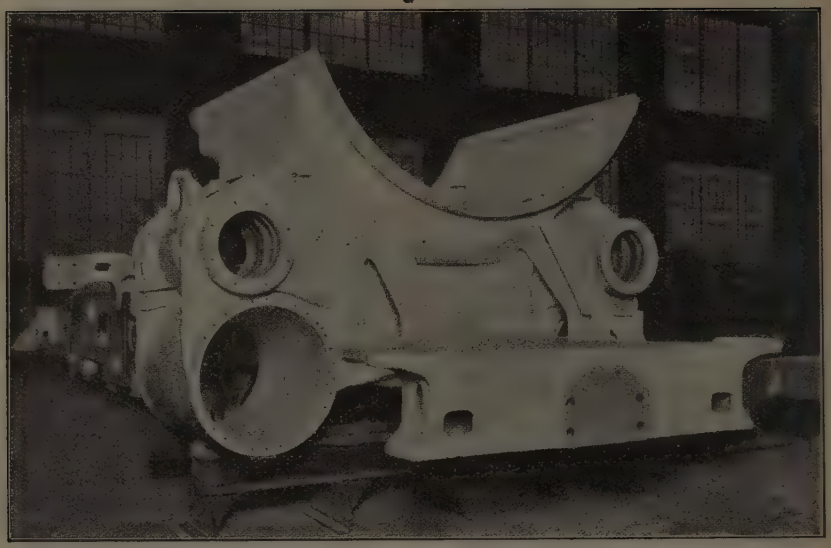


Fig. 3. — Cylinder and frame casting for 4-6-2 locomotive.

with light weight crossheads running in three bar guides. Throughout the design attention was given to the saving of weight, and, with this in view, a novel feature introduced was the flanging of the throat plate forward in the form of a saddle, to receive the rear barrel course, and the shaping of the latter at the top to provide a landing for the top of the Belpaire firebox. This method of construction saved weight, by dispensing with the throat plate connection normally employed for the square-topped firebox.

Tests on the plant at Altoona proved the high efficiency of the design, for by developing a maximum of 2 488 cylinder horse-power, a record was established for engine weight per horse-power, which worked out at 96.5 lb.

Returning now to the Pacifics, the next development was in the building at the Altoona shops of the first of the class K4.s. locomotives in 1914. This engine was designed with the idea of improving upon the performance of the earlier 4-6-2 classes, and with the object of providing materially greater power, not only at starting, but at speed, hence the cylinders were enlarged, and the heating surfaces and grate area increased.

The new engines, in many respects, bore a marked resemblance to the E6.s. Atlantics, the same refinements in design being incorporated. The light-weight motion, with underhung crosshead, and three bar guides, as for the E6.s. reappeared, and the construction of the boiler was also similar to that employed for the Atlantic, except that, in this instance, the throat and bottom half of the rear barrel section were in one plate. The rear truck, like the E6.s. design, was composed of a cast-steel frame in one piece, the sides of wich also served as equal-

isers, the main engine frames being directly supported upon them through combined sliding and spherical seatings. This design is now standard on the Pennsylvania.

When built, the K4.s. Pacifics were the most powerful of their type, that is, for locomotives having large wheels, intended for high-speed services, the tractive force being 44 460 lb., a figure made possible by the axle loads employed averaging 30 tons per axle.

On test, the K4.s. engine developed a maximum of 3 184 I. H. P., or 1 H. P. for each 97 lb. of engine weight, being, therefore, about equal to the E6.s. Atlantic in this respect.

Later engines have undergone slight modifications, such as the introduction of a power reverse gear, in place of a wheel and screw, and some have been fitted with underhung crossheads having multiple sliding surfaces working in special guides, but for the most part they are as originally built (1).

Pacific locomotives, class K5.

In designing the Pacific type locomotives class K5, a photograph and diagram of which are given, certain changes of importance have been made, compared with the original K4.s. class. These modifications include an increase in steam pressure from 205 to 250 lb. per square inch, and the substitution of a superheater of the E type for one of the A type. This change has resulted in an increase in both the evaporative and superheating surfaces, and the boiler capacity has been further augmented by the fitting of a feed-water heater. The smokebox arrangement has been redesigned, and includes a chimney of enlarged diameter, with a new form of blast pipe, the object of which is to reduce back pressure for a given draught and evaporation.

In the matter of construction, the out-

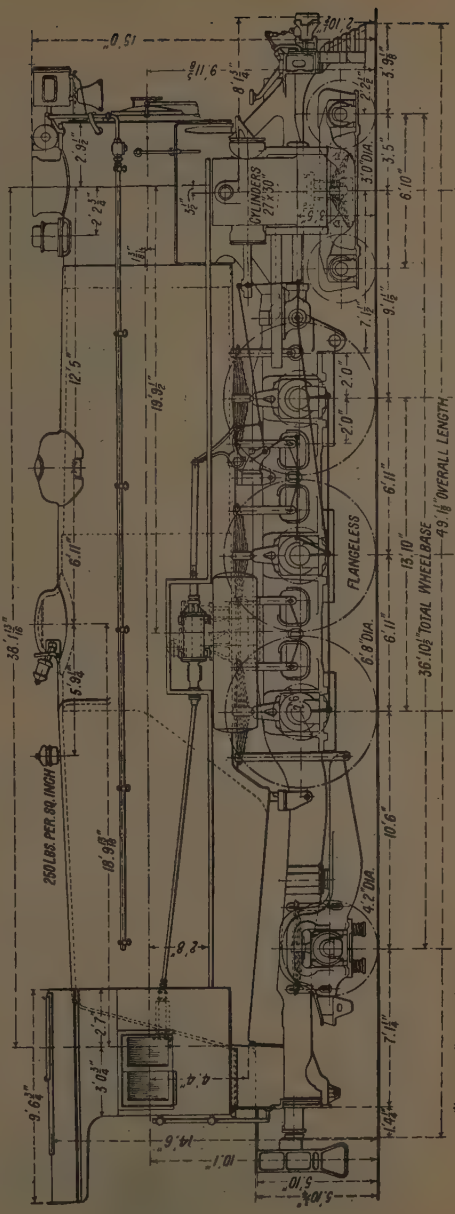

CYLINDERS 27"x30"
FLANGELESS
250 LBS. PER SQ. INCH
WEIGHT IN WORKING ORDER 254 T
OVERALL LENGTH 49' 1⅛"
TOTAL WHEELBASE 36' 10½"
142' 2T. TOTAL = 24' 2T.

Fig. 4. — Dimensioned outline diagram of Class K5 Pacific locomotive.

(1) See *The Railway Engineer*, January and March 1928.

standing changes are the use of nickel steel for the boiler barrel, and the one-piece engine framing, which provides in one steel casting the whole of the framing with cross stretchers, the cylinders and saddle, and also the hind end for the firebox support. The cylinders have been enlarged by adding to the piston stroke, and the valve gear has been arranged on the limited cut-off principle.

TABLE I. — **Dimensions of Pennsylvania Pacific type locomotives.**

Date when first built . . .	1907	1911	1911	1913	1914	1929
Class	K28	K2 (1)	K2.s.a.	K3.s.	K4.s.	K5
Cylinders	24 × 24	24 × 26	24 × 26	26 × 26	27 × 28	27 × 30
Drivers, diameter.	80	80	80	80	80	80
Steam pressure	205	205	205	205	205	250
Rated tractive effort . . .	32 620	32.620	32.620	38 283	44 460	54 675 (2)
Total heating surface . . .	4 448	4 482	4 461	4 461	4 984	5 919
Grate area	61.86	55.38	55.38	55.38	69.18	69.89
Weight on drivers, lb. . .	182 100	188 000	191 000	196 300	201 830	207 600
» » tons. .	81.3	83.8	85.2	87.5	90.0	92.5
Weight of engine, lb. . .	273.600	283.000	297 000	293 600	308 890	318 700
» » tons. .	121.7	126.2	132.5	131.1	138.6	141.9
Engine weight / Total heating surface. . . .	61.4	63.2	66.5	66.7	62.1	53.8
Rated tractive effort / Total heating surface. . . .	7.13	7.07	7.08	8.56	9.0	9.23
Total heating surface. / Grate area	72.0	81.0	80.6	80.6	72.0	85.0

(1) None in existence.

(2) R. T. F. 80 %. B. P., all others 85 %.

Total heating surface for K2.s.a., K3.s., and K5 includes superheater.

Reference to table I will show how the leading dimensions of the K5 class compare with K4s. locomotives, the differences being further illustrated in the following summary :

Boiler steam pressure . .	22.55 %	higher.
Total heating surface . .	18.75 %	greater.
Engine weight	3.2 %	greater.
Maximum tractive effort .	23-0 %	greater.
Adhesive weight	3.0 %	greater.

It will be noted that, although the working steam pressure has been increased by 22.55 %, and the heating surface by 18.75 %, the percentage increase in the engine weight is only 3.2, this slight increase being the more remarkable when the addition of the feed-water heating equipment is taken into consideration.

In general construction the boiler differs but little from those originally fitted to the K4.s. engines, from which it is chiefly distinguished by having the barrel portion including the combined throat plate and bottom half of the rear barrel course of nickel steel. The plates are 13/16 inch thick for the front part, and for the rear course the thickness is 7/8 inch. The maximum outside diameter is 7 feet 5 inches. The nickel steel employed has a tensile strength greater than 75 000 lb., which compares with about 60 000 for the more usual carbon steel plates (1). A representative

(1) See paper by C. McKnight and W. C. Humpton presented before the National Meeting of the A. S. M. E., Iron and Steel Division, Chicago, Ill., November 1928.

specification for 3 % nickel steel boiler material employed is given by table II.

The type E superheater is of the side header design, as used for previous Pennsylvania engines, such as the later 2-10-0 11. s. class, and the Mountain type class M 1 and M1.a. There are 170 flue tubes 3 1/2 inches diameter for the superheater

TABLE II. — **Nickel steel boiler plates. Chemical and mechanical characteristics**

Chemical properties.

Carbon	0.20 (max.)
Manganese	0.40 — 0.80
Phosphorus	0.045 (max.)
Sulphur	0.045 (max.)
Silicon	Not specified
Nickel	2.75, 3.25

Mechanical tests.

Ultimate tensile strength, lb. per sq. inch.	70 000 lb. (min.)
Yield point, lb. per sq. inch	0.5 U.T.S.
Elongation in 8-inches, per cent	20 % (min.)
Reduction in area	50 %

elements of 1 3/16 inches diameter, and in addition 90 tubes with a diameter of 2 1/4 inches. The length between tube plates is 19 feet and the fire area through the boiler is 8 square feet, or 11.4 % of the grate area. The firebox and combustion chamber is as for the K4.s. locomotives. The total combined heating surface amounts to 5 919 square feet of which 1 634, or 27.6 %, is in the super-

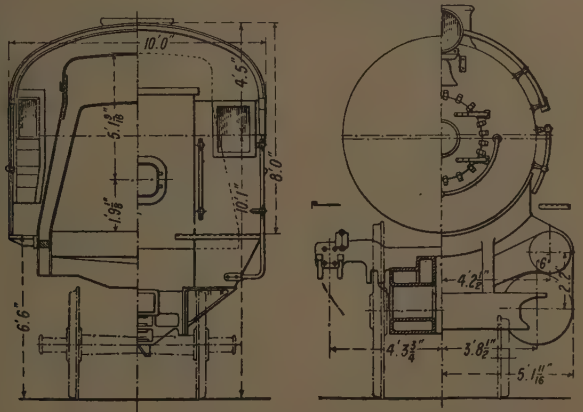


Fig. 5. — Cross sections, Class K5 Pacific locomotive.

heater. The grate has an area of 69.89 square feet, and firing is by hand.

To add further to the boiler capacity, a Worthington S type feed heater is fitted. The heater proper, or mixing chamber, is placed over the smoke-box, behind the chimney, where it can be readily piped to the exhaust passages. Cold water is

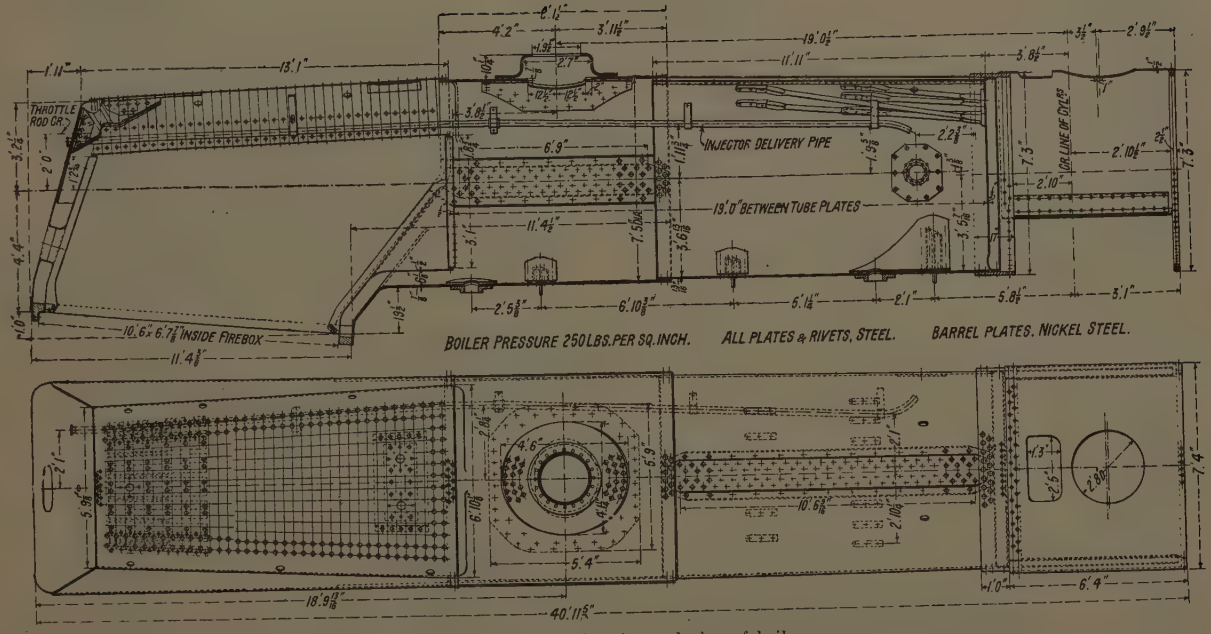


Fig. 6. — Sectional elevation and plan of boiler.

supplied to the heater by a rotary pump, driven by a Pyle-National turbine, assembled in a unit and mounted under the cab. For delivering the hot feed to the boiler, a reciprocating pump is used; this is fixed near the front of the boiler, and is controlled by a valve in the cab. Exhaust steam from the pump is turned into the heater, and an automatic control is applied, so arranged that when the main throttle is closed, or only slightly open, as when the engine is « drifting », the feed pump is slowed and the quantity of feed supplied limited. Under such conditions the amount of water pumped is small, relatively to the steam used by the pump, so that good heating of the reduced amount of feed water is obtained. The feed-water temperatures realised vary between 210° and 230° F. It is pointed out that these feed temperatures are lower than would be the case on other lines, for the reason that special attention has been given to the reduction of back pressure, which, up to about half capacity, is not more than 3 lb., and in regular service probably does not exceed 10 lb. per square inch.

The superheater delivers steam at temperatures ranging between 700° and 750° F. at maximum capacity, when the smoke-box temperatures are about 100° F. less, and at approximately half capacity the superheated steam temperature as delivered to the cylinders is about 650°, with a smoke-box temperature of some 50° to 70° lower.

The blast pipe.

With the idea of improving the draught available, and at the same time reduce back pressure on the pistons, special attention has been given to the arrangement of the chimney, and a novel form of blast pipe introduced. The chimney has been enlarged in diameter, and the blast pipe also of large over-all diameter is fitted with an annular ported nozzle, consisting of six radial openings, which converge inwards to the centre. The design which has been adopted, as will be seen from the drawing, increases the ratio of the jet periphery to its area, and at the same time nicks the periphery, thus adding to its efficiency because of the increased frictional contact between the gases and the exhaust jet. The better entraining action of the jet attained in this manner enables a larger area of

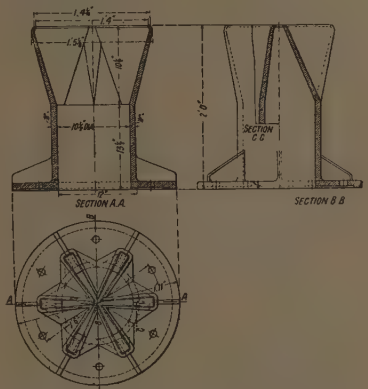


Fig. 7. — Details of new form of blast pipe used on class K5 Pacific locomotive, Pennsylvania Railroad.

the exhaust and nozzle to be used, and hence the back pressure is less for a given draught and rate of evaporation.

The engines and framing.

The cylinders are 27 by 30 inches, compared with 27 by 28 inches for the K4.s. engines, and the 12-inch piston valves are actuated by the standard design of Walschaerts motion. The valves have a full gear travel of 7 inches, and are set with a lead of 1/4 inch, and have a steam lap of 1 7/8 inches and 3/8 inch inside clearance.

In view of the good results obtained with the 2-10-0 type I1.s. freight locomotives operating on the limited cut-off

TABLE III. — Dimensions and proportions, Pennsylvania Pacific type express locomotives, class K5.

Cylinders, diameter and stroke, inches	27 × 30
Valve gear	Walschaerts
Piston valves, diameter, inches	12
Travel, inches	7
Cut-off. Full gear, per cent. Main ports.	67
Starting ports, per cent.	82

Weights in working order.

On drivers	207 600 lb. =	92.50 tons
On front truck	54 200 » =	24.20 »
On rear truck	56 900 » =	25.20 »
Total engine	318 700 » =	141.90 »
Total engine and tender	563 700 » =	250.26 »

Wheels; diameter on tread.

Drivers, diameter, inches	80
Front truck, diameter, inches	36
Rear truck, diameter, inches	50

Boiler.

Working steam pressure	250 lb. per sq. inch.
Type	Belpaire
Fuel	Bituminous
Firebox, length and width	126 by 79 7/8 inches
Arch tubes, number and diameter	Four, 3 inches
Combustion chamber length	4 feet
Tubes, number and diameter	90 — 2 1/4 inches
Flues, number and diameter	170 — 3 1/2 inches
Length over tube sheets	19 ft. 1 in.

Heating surfaces, square feet.

Firebox comb. chamber and arch tubes	305.0
Tubes and flues	3 980.0
Total evaporative	4 285.0
Superheating	1 634.0
Total combined	5 919.0
Grate area	69.89

Tender.

Weight	245 000 lb. = 109.3 tons
Water capacity	14 000 gallons
Coal capacity	36 000 lb. = 16 tons

General data estimated.

Rated tractive force (M.E.P. 80 % B.P.)	54 675 lb.
Weight proportions :	
Weight on drivers / Total weight of engine	0.65
Weight on drivers / R.T.F.	3.80
Total weight of engine / Comb. heat. surface	53.84

(1) Including combustion chamber and arch tubes.

Boiler proportions.

Tractive force / Comb. heat. surface	9.24
Tractive force × diam. of drivers / Comb. heat. surface	739.00
Firebox heat. surface (1) / Grate area	4.36
Firebox heat. surface (1) / Comb. heating surface per cent.	5.15
Comb. heating surface / Grate area	85.00

principle, this system has been adopted for the new Pacifics and the normal full gear cut-off is 67 %, auxiliary ports being arranged in the valve liners, giving a starting cut-off of 82 %. These starting ports are, however of small dimensions, and, after the first few revolutions, the amount of steam which passes through is so much reduced by wire drawing as to have no effect on the indicator cards. Limiting the full gear cut-off in this manner not only reduces the steam rate per unit of power at the nominal maximum cut-off, but allows of larger cylinders being used, and thus for the same cut-off greater power is available, or for the same power shorter admissions may be employed. The driving wheels have a diameter of 6 feet 8 inches, and, with the working pressure of 250 lb. per sq. inch, the tractive effort is given at 54 675 lb. (1) compared with 44 460 lb. for the K4.s. class, calculated on a mean pressure of 85 % of the boiler pressure.

The tractive effort of 54 675 lb. is high for a 4-6-2 type engine, and is believed to constiute a record (2) and the axle loading allowed, averaging 69 183 lb. each, is the factor which makes such a great tractive effort possible.

Actually, the total weight on the coupled axles is 207 600 lb., or 92.5 tons, giving an adhesive factor of 3.80, so that the available weight is fully utilised. The motion is of a specially light design, and the material used complies with the Pennsylvania standard specification for carbon steel, grade B, for quenched and tempered, or annealed forgings for locomotives and cars. The chemical requirements are as specified below :

Carbon steel, grade B.

	Min.	Max.
Carbon, per cent.	0.40	0.55
Manganese »	0.40	0.70
Silicon »	0.10	0.30
Phosphorus »	—	0.05
Sulphur »	—	0.05
Chromium »	—	0.30
Nickel »	—	0.40

Floating bushings are applied to the main pin bearings for the connecting

(1) The coefficient C for the M.E.P. corresponding to a full gear cut-off of 82 % is taken as 80 %, estimated thus :

$$C = \frac{2}{E+1}, \text{ and for } 82\ \%,\ E = \frac{1}{0.82} = 1.21\ C$$

$$= \frac{2}{1.2+1} = \frac{2}{2.21} = 0.90.$$

M.E.P. at the rim of the drivers allowing 10 % for machine friction becomes therefore 0.90 × 0.90 = 81 %, or, say 80 %.

(2) The « President » class 4-6-2 engines of the Baltimore & Ohio, built in 1927, have 50 000 lb. R.T.F.

rods, and also to all the coupling-rod bearings, and the cross-heads are of the Duplex type, having multiple bearing surfaces, as introduced for the later I1.s. and K4.s. engines, and for the 4-8-2 engines, class M1 and M1.a. The valve motion is operated by a « Precision » power gear.

The one-piece engine frame casting comprises the cylinders, with valve housings, and saddle, the whole of the cross braces, link supports, guide yokes, the front bumper and the footplate. The material is cast steel, with a tensile strength of about 60 000 lb. and 35 % elongation.

In the arrangement of the spring suspension and of the leading and trailing truck assemblies, Pennsylvania standards are followed. The spring compensation extends from the leading coupled axle to the rear truck, and takes the weight through combined sliding and spherical bearings, one on each side member abutting on the underside of brackets solid with the rear side rails of the main framing. The driving axle journals are 11 1/2 by 15 inches, and those for the other coupled axles are 11 by 15 inches. For the front and rear trucks the journals are 6 1/2 by 12 inches.

The tenders are of unique design especially so far as the main framing is concerned. The frame is a unit casting of steel without side sills. The draught gear pockets are cast integral for the drawgear at each end, and at the bogie centres side bearer arms solid with the main casting extend outwards. The tank is strongly braced internally, and in such a manner that all strains are transferred to the centre frame member. The trucks are of the four-wheeled type, and have unit cast-steel Commonwealth-type framing; they are equipped with 36-inch wheels of rolled steel. The light weight is 91 600 lb., or 40.7 tons, and, when full, the weight is 245 000 lb., equal to 109.3 tons.

These Pacific-type locomotives are in certain respects the most noteworthy thus far built, being, from the point of view of tractive effort, the most powerful yet constructed. They are believed to have more heating surface than any other 4-6-2 engines.

Probably the chief factor governing the design is the high loading allowed for the coupled axles, as this permits of the tractive effort of 54 675 lb., and at the same time allows of the retention of the Pacific wheel plan, as against the 4-6-4 arrangement.

Of the total engine weight, 65 % is carried by the coupled axles; thus the loading of the leading and trailing trucks is quite normal, being, in fact, less than is found for many other Pacifics of less capacity. The weight per square foot of combined heating surface is only 53.8 lb., and this, taken with the proportion of the total weight carried on the coupled axles, together with the low factor of adhesion of 3.80 made possible with the limited cut-off, indicates the care taken in working out the design.

Other factors which are responsible for the results obtained, are, of course, the special steel used for the boiler barrel, and the unit main frame construction, both of which materially reduce weight.

The leading dimensions and ratios of these locomotives are given in Table III.

The photograph of the engine, with the drawings, have been courteously furnished by Mr. F. W. Hankins, who also provided particulars of the earlier locomotives given in table I, and the General Steel Castings Corporation, and the International Nickel Corporation supplied the photographs of the engine-frame casting, and the boiler respectively.

[656. 212 .5]

The technique of marshalling in goods yards in the light of rationalisation and mechanisation.

by Herr KAEMPF, Baurat, Berlin.

(From the *Zeitschrift des Vereines Deutscher Ingenieure*, vol. 74, No. 51.)

Numerical data on the subject of marshalling yards and their division into level and incline yards, are given hereafter and followed by particulars on the equipment, apparatus, work of alteration and methods of operation of both types of yard, necessary to ensure the rapid transit of wagons through the yards, notwithstanding their varying resistances to running and distances travelled. These measures are intended to reduce the time of « turn round » and to improve the utilisation of the wagon stock, simultaneously with a reduction of the operating costs.

There exist in Germany about 120 sorting yards with a daily capacity of more than 2 000 wagons each, and of these again, 30 can deal with more than 4 000 wagons each per day. The sidings of these sorting yards are as a rule divided into reception, sorting and despatching lines. It must here be emphasised that the connections between these reception, sorting and dispatching sidings, usually consisting of one or more roads over which all wagons must pass, form to a certain extent the heart of the yard and as such must, therefore, receive the greatest consideration. The marshalling of the wagons by destination stations, is either carried out at the end of the sorting grid of the despatching yard or on an intermediate group of roads specially intended for sorting in stations order.

There are two types of modern marshalling yard; yards on the level and incline yards. Level yards (fig. 1) may be divided into almost equal classes, one- and two-sided; under this latter head come double layouts which can be worked in two directions independently (fig. 2).

Method of operation of shunting yards.

Level yards. — If the approach sidings do not already lie on the side of a hill (fig. 1), a small hump is built between the reception sidings and the sorting sidings (fig. 3), The shunting engine pushes the train, which has been placed in the reception yard, over this hump so that the uncoupled wagons can be run into the sorting yard. The foreman shunter conducts this sorting operation from the top of the hump and gives the driver signals as to speed which ranges between two to five feet per second. The wagons travel through the sorting points — the danger zone — with a speed in accordance with that at which they are pushed off, the height of the hump and the incline. The fixed point from which the wagon is started lies somewhat below the top of the hump; varying wagon resistances and wind cause small variations in speed.

Incline yards. — These lie on regular slopes whose angle of inclination must be sufficient to overcome the wagon resistance (fig. 4). Unbraked wagons therefore start to run by gravity. There are five such yards in Germany, of which only one can be termed a true incline yard, the other four being mixed installations. For sorting, the train, at a stand but with brakes set, is attended by a number of brakesmen, who acting under orders from the foreman shunter give the train the requisite velocity by

applying or releasing the brakes. After retarding the front part of the rake usually by placing a scotch or sprag in one of the front wheels of the foremost group of wagons, it is then possible to unhook the coupling of that group, so that it may be run off into the designated siding. This particular system permits of the possible variation of the point at which a wagon is cut off, over a wide range, so that the cut-off can be made at a point to suit the siding for which that particular wagon is destined.

The question as to which of the two types of yard should be prefered has not yet been determined. Both have their advantages and disadvantages.

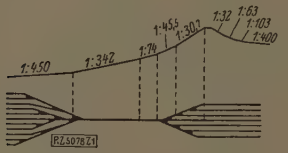


Fig. 1. — Level yard with ramp on reception sidings.

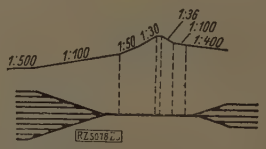


Fig. 2. — Level yard with hump.

Fig. 3. — Level yard with double layout.

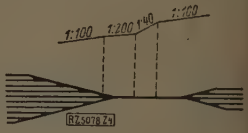


Fig. 4. — Incline yard.

The lie of the land will very often determine the system to be adopted. Recent investigations tend to show the incline yard in a very favorable light and rate it as superior to the level yard.

Mechanisation of marshalling operations.

Problems and aims.

It would be a simple matter to master the technique of marshalling if all wagons had the same distance to travel and had the same rolling resistance. The sorting sidings are of the same length as a train. The range of movement of a wagon varies around 600 m. (2 000 feet) and its resistance to motion is dependent on design, condition and load, on the number of curves and points it passes through, on the occupation of the track by other vehicles and on the time elapsed between the arrival of the train and the commencement of shunting operations, etc. There are consequently good and bad running wagons, and wagons having a short or a long distance to travel (1). It is therefore understood that the profile of a yard can only be worked out for one particular wagon under a particular set of conditions, while for the bulk it can only be an approximation.

As in an average turn-round of seven

(1) See WENZEL, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 68 (1924), p. 986.

days, a wagon only runs about three hours per day and stands for the other 21 hours in stations, in sidings and at loading platforms, an increase of the running speed of goods trains is not of such paramount importance, as a reduction of the time spent in marshalling yards. The movements to and from yards are easiest to control. Difficulties arise during the passage through the yards and again especially when entering the sorting sidings. The wagons must not come to a stand too soon, either on crossovers where they will block the points, run on the wrong roads, cause side collisions and derailments and prevent the filling up of the sidings, nor must they come to a stand in an isolated position, as in that case they would have to be brought together by a shunting engine and the business of marshalling would be interrupted. The wagons should come buffer to buffer to facilitate coupling up and should follow one another in rapid succession. This rapidity should not, however, be such that the wagons overtake each other on the points and collide and so damage themselves and their contents. The intervals between a bad running and a good running wagon following it, must above all things permit the safe movement of the points and a clear passage through them.

Three conditions are necessary for economical marshalling :

Regulation of the running time, i. e. the intervals between wagons in the danger zone, in order to prevent overtaking on the points and to ensure time for operating the points between succeeding wagons.

Regulation of the length of run, i. e. bringing the wagons to a stand without shock and in close contact so as to make coupling up quick and easy.

Shortening the time between each cut.

The output of the yard depends on the fulfilment of these three conditions.

Methods of carrying out the mechanisation.

The reception sidings.

As stated above, the foreman shunter must be able to regulate from the point the cut is made, the speed of the engine, by means of visible or audible signals, to the driver or to the brakesmen operating the train. This transmission of orders is hindered on occasions by inattention of the staff, by unfavourable wind, fog, etc.

In order to improve matters, trials were undertaken with wireless transmission and good results were obtained. An insulated wire is suspended alongside the arrival siding and this is earthed at both ends. Electric power fields are set up in this conductor when the foreman shunter opens or closes a switch and these transmit signals which are picked up by an antenna on the engine. The orders are then transmitted as signals to the driver through an amplifier and loud speaker.

In another system, an antenna is stretched between the engine chimney and the driver's cab and the cab is fitted with a receiving set and loud speaker. The foreman shunter then gives his orders by word of mouth. By this means improvements in communications have already been achieved.

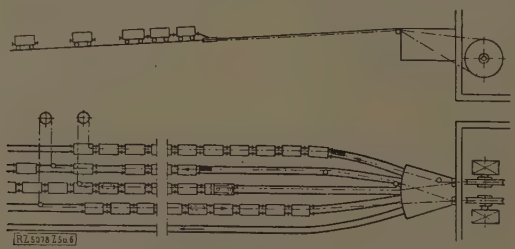
The steam locomotive, however, still remains uneconomical for this kind of service because it is not designed for such low speeds and because two men are required to operate it and, to permit of coaling and watering as well as fire cleaning, a relief engine is required (2). It is much better and more satisfactory when the foreman shunter himself can handle the train by means

(2) Regarding the recent motor locomotives for station work, of the German State Railways, see NIEDERSTRASSER, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 74 (1930), No. 50, p. 1697.

of a special machine and so avoid the necessity for a driver, a fireman and a brakesman.

Two methods of breaking up trains controlled from a distance have proved to be very satisfactory at incline yards. In one of them (3) a four-wheeled bogie runs on a narrow gauge track in the center of each arrival road; it is so constructed that it can be lowered to clear the gauge. When it is raised it engages with the buffers and is then connected with the draw hook of the last wagon of the train which is standing with brakes applied.

Two roads are so arranged that an endless wire rope draws one bogie downwards while another is drawn in the opposite direction on the other road (figs. 5 and 6). The speed at which these bogies travel is regulated by the foreman shunter by means of the driving sheave. The bogie is more or less capable of controlling a train with the brakes off or a train without brakes but it can also if necessary impart an increased speed by pushing. Uncoupling and running off are effected in the same way as in the systems described above. The foreman can, in this as in all other incline systems, select for the cut of any group, the most suitable point during the descent. It may be credited to this system, as a second advantage, that in the case of suitable distribution of work in the yard, no costs for current but rather savings of current result as the braking energy is returned to the line. As compared with other incline yards, where the weight of the wagon alone overcomes the wagon resistance, such an installation can, on account of the application of pressure, have a smaller inclination of the arrival ramp and the elevation of the hump can therefore be less.



Figs. 5 and 6. — Incline yard with run-off installation, rope drive and travelling bogie.

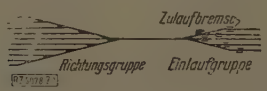


Fig. 7. — Incline yard with run-off installation and retarders.

Explanation of German terms:
Einlaufgruppe = Run-off sidings. — Richtungsgruppe = Sorting sidings. — Zulaufbremse = Retarder.

In the other installation, retarders are provided in each road, at the run-off point (fig. 7), which brake the head of the train and keep the couplings tight, and 4-beam retarders are used as will be more fully described hereafter. The speed at which the wagons, uncoupled by groups and unattended by brakesmen, run off the incline, is regulated by the foreman shunter by varying the pres-

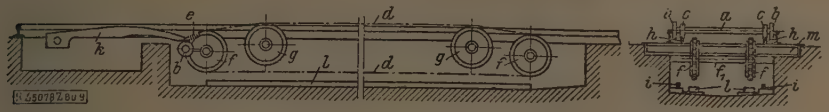
(3) Frohne, *Verkehrstechnische Woche*, vol. 23 (1929), p. 128.

sure in the retarders. Advantage is obtained from the stored up energy in the buffer springs, set loose when the brakes are taken off, as it assists gravity to overcome running resistance. This arrangement also permits of a smaller incline and less height of ramp. The run-off point, however, remains the same.

Whereas the two appliances are tied to fixed positions, the remote control electric pushing and shunting locomotive can be applied to the performance of any kind of work in both types of yard. It is fed by an overhead line or by storage batteries. The reception sidings are equipped with a trolley line. The speed of the locomotive, that is to say the push-off speed of the train, is regulated by the foreman shunter by altering the pressure of the current on the Leonard system. All other movements of the engine, transfer to a fresh train and all other possible operations in the yard are controlled by the man on the engine by means of current from accumulators, which are kept charged by a Diesel-motor driven dynamo.

Gravity shunting.

The height of the hump is usually such, that good running wagons reach the furthest limit. Bad runners, in unfavourable conditions, sometimes remain almost at the foot of the hump. If these bad runners are at least to pass beyond the danger zone or even as far as the second half of the sorting sidings, some alteration in the run-off is necessary.



Figs. 8 and 9. — Accelerating apparatus.

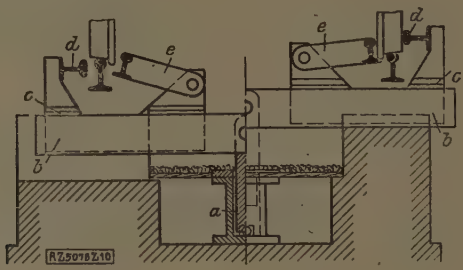
a = Pressure shaft.
b = Pressure rollers.
c = Rollers carrying the pressure shaft, omitted from fig. 8.
d = Chains, omitted from fig. 9.
e = Spring couplings between chain and pressure shaft.
f = Chain wheels.
f_1 = Chain wheel shaft.
g = Pulleys for changing direction of chains.
h = Upper guide rails for pressure shaft.
i = Lower guide rail for pressure shaft.
k = Levers operated by wagon wheel flanges and pressure rollers for making shockless contact between pressure rollers and wheel flanges.
l = Lower guide rails for chain.
m = Supporting beam.

The accelerating apparatus, shown in figures 8 and 9, improves the « run-off » without it being necessary to alter the lay-out of any one of the existing yards. This apparatus (4) which is inserted in the road below ground level, close to the run-off point, consists of a shaft a fitted at either end with loose pressure rollers b which are hauled by means of two parallel endless chains d; the acceleration is transmitted by the pressure rollers to the wheels of the wagon. In the preliminary or « ready » position, the pressure shaft lies close to the upper shaft but slightly below the level of the foot of the rail (fig. 8). The foreman shunter sets the control to provide the required amount of acceleration, before arrival of the wagon to be dealt with. The passing of the wagon itself closes the circuit to start the motor by depressing a contact; in the same way, in passing over an operating crank, it brings the pressure rollers into contact

(4) KAEMPF, *Verkehrstechnische Woche*, vol. 23 (1929), p. 133.

Fig. 10. — Hydraulic-power track brake (retarder).

a = Lifting piston.
b = Rising and falling supporting beams.
c = Adjustable brackets.
d = Fixed brake beams.
e = Moveable brake beams.



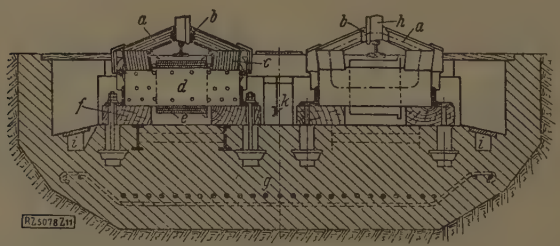


Fig. 11. — Eddy current brake.

a = Brake beams with thick outer and thin inner plates.
b = Filling pieces.
c = Laminated plate guides for parallel movement of brake beams.
d = Magnet core.
e = Exciter winding.
f = Layer of insulating material
g = Foundation.
h = Wagon wheel.
i = Cable duct.
k = Arrangement for lowering brake beams to clear gauge.

with the wagon wheel flanges without any noticeable shock. The finely adjustable regulation permits of the acceleration of a bad running wagon up to a speed of 8 m. (26 feet) per second.

While this apparatus accelerates bad running wagons so that good and bad wagons shall have a similar range, the same result can be achieved by increasing the height of the hump, until the bad runners attain the same length of run as that formerly attained by the good runners. The good runners must then be braked at the foot of the hump. As the distribution of the fall over the length of the run has a very considerable influence on the time elapsing between buffer contacts, it is necessary to investigate closely the amount of fall before converting a hump or building a new one. The difference in the running speeds of wagons, as a result of their varying running capacities, becomes less as the running speed is increased. If, consequently, a wagon passes through the danger zone at high

speed, overtaking of the previous wagon is prevented. On this account the hump should be designed with a steep fall.

For heavy braking at the foot of the hump, four beams from 10 to 20 m. (33 to 66 feet) long, controlled from a distance, are arranged to be pressed against the tyres of the wagon wheels at a little above the level of the rail (fig. 10).

In one design of this brake (5) beams *b* capable of being raised or lowered by means of a pressure cylinder *a* are installed in a pit below rail level. These carry brackets *c* which gripe the rails. Brake beams *d* are attached to the brackets, the one being fixed and the other moveable, supported by a spring. The moveable brake beam carries on its upper part a rail on the foot of which the tyre flange of the wagon to be braked mounts and so forces the beam downwards. By this means the wheels are braked. The greater the pressure in the lifting cylinders, the harder the four brake beams are pressed against the wagon tyres. The braking force can therefore be regulated between zero and maximum. If the pressure is excessive, the wheel will begin to lift. At the instant when the tyre flange leaves the foot of the moveable rail, the pressure becomes nil and the lifted wheel falls again. The maximum braking power is therefore dependent on wagon weight. If locomotives have to pass the brake, the brake can be lowered clear of the gauge.

The latest of this type of brake is the eddy current brake (fig. 11) (6). In this type also four brake beams are provided which rest on the poles of U-shaped magnet cores, to which they are so connected that they will easily move to accommodate the varying tyre widths, differences in the distance between the inner faces of tyres, and the side oscillations of passing wagons. The brakesman varies the current in the coils to suit the brake power required.

The strong magnetic current holds the beams vertically on the pole pieces without other fastening and tends to draw them together horizontally. A stop prevents too close approach, which would prevent entry of the wheels into the brake. The brake beams, acting through the excited coils as pole rails, adhere strongly to the wheels of the passing wagons. As the lines of force pass through the wheels, eddy currents are created, which act very strongly to prevent movement. More than 80 % of the braking effort is provided by these eddy currents, while the balance is mechanical. This small percentage of mechanical work done has the advantage that there is no wear and the axles are not submitted to bending stresses.

As soon as the current is interrupted, the beams are drawn apart by springs. In the case of this brake also, the gauge is cleared by lowering the brake beams. It is not possible to derail a braked wagon. A further advantage is that the wagon is neither raised or lowered on entering, passing through or leaving the brake, so that there is no rolling nor pitching of the wagon.

A special system of shunting is the « controlled system » (fig. 12) (7). Under this system the sorting sidings must be connected with two sets of points coming from the hump, and besides which small trolleys fitted with folding arms, run on an endless guiding track.

As these trolleys stand in the ready position, the arms are vertical and clear of the gauge. In operation, the arm is raised to the horizontal and engages the wagon to be controlled at about the buffer

(5) FROELICH, *Organ für die Fortschritte des Eisenbahnwesens*, vol. 55 (1918), p. 67, and WENZEL, ditto, vol. 68 (1924), p. 987.

(6) MEYER, *Verkehrstechnische Woche*, vol. 23 (1929), p. 148.

(7) H. SCHMUCKLER, *Verkehrstechnische Woche*, vol. 19 (1925), p. 27.

height. The shunting foreman intercalates, in front and behind each separate cut of wagons, one of these trolleys which is automatically coupled to an endless rope. All cuts run off singly or in groups, thus travel at a similar speed, which can be regulated, and overtaking is rendered impossible. At the points of diversion, the wagons release themselves and run into the sorting sidings. At the end of the points zone, the trolleys return to their starting point where they are released from the rope and stored ready for use again.

Sorting sidings.

The above described arrangements regulate the running time. The second consideration, the regulation of the distance travelled, has so far been met by pushing up the wagons by a shunting engine, when they remain isolated on

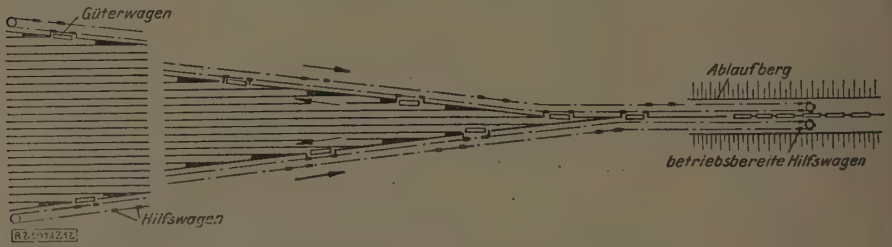


Fig. 12. — Shunting installation of the « controlled system ».

Explanation of German terms:
Ablaufberg = Hump. — Betriebsbereite Hilfswagen = Auxiliary trolleys ready for use. — Güterwagen = Goods wagons.

the road or by laying down scotches, when it appears probable that the wagon is likely to overrun, whether it be on account of short sidings or on account of good running capacity. The run-off may therefore be carried out on the basis of either of the following two possibilities : The wagons may either be allowed to stop individually, short of their intended point, and be subsequently brought together, or they may be given an excess velocity so that they have to be braked to their point of destination. Accumulator- or petrol tractors running in the six-foot way are used *to collect wagons* (8). The only possibility of tranferring the long and heavy accumulator tractors from road to road is by means of points at the end of the grids. As to make the changeover it is necessary for these tractors to travel long distances, it is essential that they should be able to travel at considerable speeds when running light. Petrol tractors, on the other hand, can cross the rails by means of ramps of the required height at any suitable point. Such ramps may conveniently be placed in the first half of the sorting grid as the majority of the work is done in that area.

Closing up of wagons can also be carried out with a Lückenschliesser (gap closer) (9) which runs on two rails fixed to the sleepers below the buffers. The gap closer is operated by a motor with distant control, through the mé-

(8) KAEMPF, *Organ für die Fortschritte des Eisenbahnwesens*, vol. 66 (1929), p. 233. See also footnote No. 2.

(9) ZOOHE, *Verkehrstechnische Woche*, vol. 23 (1929), p. 162.

dium of an endless rope. A short rope is used to haul the wagons.

Similar results are also obtainable with « shunting bridges » and the « endless rope » layouts. A bridge is provided spanning the first one third of the sorting sidings (fig. 13) on which, one or two hauling crabs move, each fitted with one barrel wound with heavy wire rope and another barrel with a light auxiliary rope (10). A light hauling rope is installed between every second six-foot way, and this is carried round a winch at the upper end of the sorting sidings, the two ends passing over vertically placed snatch blocks below the bridge. When the crab has been brought above the siding on which it is desired to close up the wagons, the rope is run out by the auxiliary rope and attached to the wagon draw hook and the heavy crab then hauls the wagon under the bridge. At the same time the auxiliary rope is returned to its ready position and when the ropes have been uncoupled the crab can carry on with the work.

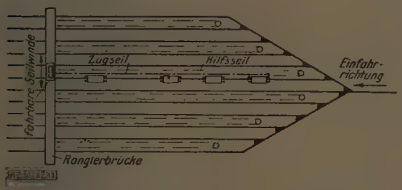


Fig. 13. — Shunting bridge with rope crabs for closing up wagons.

Explanation of German terms:

Einfahrrichtung = Direction of entry. — Fahrbare Seilwinde = Moveable rope crab. — Hilfsseil = Auxiliary rope. — Rangierbrücke = Shunting bridge. — Zugseil = Hauling rope.

The shunting layout with endless rope (fig. 14) consists of a powerful motor winch working an endless hauling rope and a smaller one, always kept in motion, working an auxiliary rope (11), which runs on snatchblocks in the six-foot and travels, like the hauling rope, across and below the tracks in a transverse duct. The auxiliary rope hauls the hauling hook along this duct to the road to be worked on, and the hook is

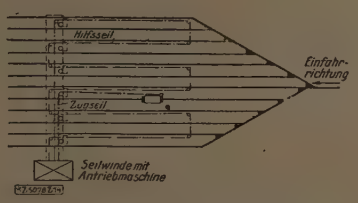


Fig. 14. — Shunting arrangement with endless rope.

Explanation of German terms:

Seilwinde mit Antriebmaschine = Rope winder with driving mechanism.

(*Others as in fig. 13.*)

there disconnected and is lifted through an opening and again connected to the rope working that road; it is now hauled out and connected to the wagon to be closed up and the hauling rope then closes the wagon up.

Under the second system of operation, where the wagons are accelerated to attain equal running speed, those which run too far must be brought to a stand. This is arranged by means of slippers, « brake dogs » or brake beams operated from a distance, from a tower. Slippers may be divided into three types (12). The simplest type provides only a fixed braking length (fig. 15).

Two sets of different braking lengths are therefore sometimes arranged one

(10) *Verkehrstechnische Woche*, vol. 19 (1925), p. 73.

(11) H. Lange, *Verkehrstechnische Woche*, vol. 19 (1925), p. 40.

(12) W. Kaempf, *Organ für die Fortschritte des Eisenbahnwesens*, vol. 65 (1928), p. 79 and vol. 67 (1930), p. 195.

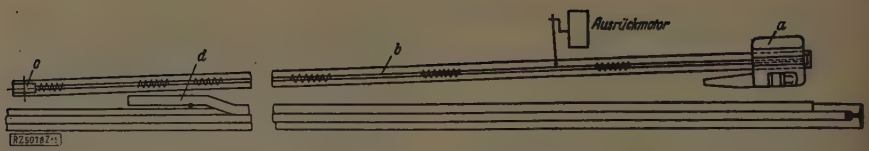


Fig. 15. — Slipper with fixed braking length.

Explanation:

a = Slipper which can be moved to *b*. — c = Pivot of the guide tube *b*.
d = Wing rail.
Ausrückmotor = Throw-out motor.

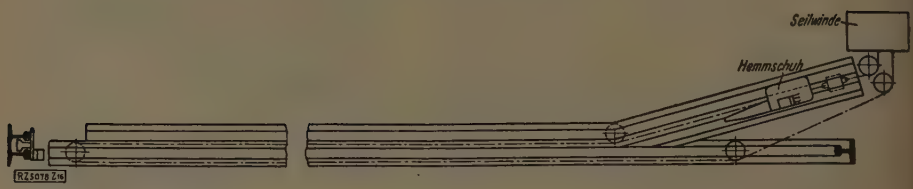


Fig. 16. — Slipper brake with which the length of the braked distance can be varied.

Explanation of German terms:

Hemmschuh = Slipper. — Seilwinde = Winch.

Figs. 17 and 18. — Slipper with which the braking length can be varied *during* braking.

behind the other and even three different braked areas can be arranged in this way.

The slipper *a* has a socket-shaped attachment which slides on a long tube *b* lying at one side of, and parallel with, the running rails. This can be rotated round its pivot *c*. When in the ready position, the slipper lies on the running rail. At the end of the braking length it is taken from below the wheel and guided onto a wing rail *d*. The springs fitted on the tube are compressed during braking and return the shoe to its ready position after the brake has been thrown out.

In order that the braking position may be predetermined, with the possibility of either altering it or rendering it inoperative, the slipper in the second design is coupled to an endless rope, as is shown in figure 16. By means of a « braked section selector » it is possible to advance or retire the slipper as may be desired. The wheel travelling on the slipper disconnects the shoe from the rope and forces it on to the wing rail in the ready position.

In the third type of slipper brake (figs. 17 and 18), it is possible to interrupt the braking action at any desired moment [13]. With this object in view, the guide rail which lies alongside the running rail and which is griped by the shoe, can be moved sideways and thus withdraws the shoe from beneath the wheel. The shoe is then connected to an endless rope which returns it to the ready position.

Figs. 19 et 20. — « Brake dog » with remote control.

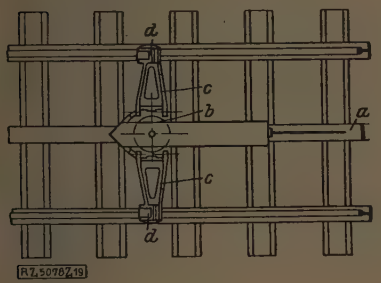


Fig. 19.

Fig. 20.

a = Flat iron plate guiding the brake.
b = Moveable steel member.
c = Arms with vertical and horizontal movement, carrying brake blocks *d*.

A very remarkable development is the « brake dog » with remote control (figs. 19 and 20) [14], a variation of the slipper brake, which, in addition to mechanical friction, employs electromagnetism and eddy currents.

A steel member *b* with two revolving arms *c* carrying brake blocks *d* at their ends, travels on a flat guide bar *a* fixed to the sleepers midway between the running rails; the brake blocks have no ramps but have horizontal hinges so that the height of the blocks can vary. When moved diagonally forward and lowered, they are clear of the gauge, but when at right angles on the rails they are in braking position. They are connected to one another by electro-magnets but they can nevertheless be rotated round the vertical pivot, so that they are not stressed.

When the « brake dog » is being accelerated, the oncoming wagon forces the arms to a certain extent in the running direction. On this acceleration section the guide rail is non-magnetic, so that on this section the « brake dog » cannot be braked here. Coils are fitted in the steel frame, which when excited provide the braking force. When deceleration appears to be sufficient, or automatically at the end of the braking length, interruption of the current unlocks the coupling of the arms and the wagon can then run freely past the dog.

The braking force arises from the resistance between the dog and its brake rail, i. e. through friction and eddy currents, from the friction between the brake blocks and the running rails and between the wagon wheels and the brake blocks.

At the beginning it was pointed out that *unfavourable* winds interfered very greatly with the run-off. To combat this interference, trees and especially poplars, have been planted in several yards. As however, the tree growth is slow, recourse has been had to wind screens [15] made up of laths 4-5 m. (13 to 16 1/2 feet) high. As a result of aerodynamic investigations, it has been pro-

(13) Dietrich, *Verkehrstechnische Woche* vol. 20 (1926), p. 477.

(14) E. Hering, *Organ für die Fortschritte des Eisenbahwesens*, vol. 66 (1929), p. 227.

(15) D. Oeser, *Verkehrstechnische Woche*, vol. 19 (1925), p. 15 und C. Pirath, *ditto*, vol. 23 (1929), p. 164.

ved that the wind eddies on the lee side of these screens reduce the wind effect by as much as 80 %. These screens are erected across the prevailing wind direction and care must therefore be taken that unfavourable surfaces are not presented to winds from other directions. Care must naturally be taken not to obstruct the view of the shunting and point operating staff. Lath screens can be used because it is possible to see through them quite well. At yards where the prevailing direction of the wind is opposed to the run-off, screens have been erected across the neck of the sorting grids above the moving gauge.

It goes without saying that the rapid movement of wagons, made possible by all these provisions, should on no account be negatived by the slow working of the points; it is therefore obvious that hand operation must be cut out and only power operation used because, while the distance of the points from the operating base is of no importance when power is used, the collection of several small units into a larger one is rendered possible.

Point operating installations for the run-off.

Point arrangements for sorting differ from those installed for train operation and their separation is therefore essential. As a result, the work of the shunting pointsman is specialized. By installing the operating mechanism in a suitable position it can be so arranged that one man can operate all the points to be dealt with.

It has been found possible to build electric motors which can reduce the time required to set the points, from 3 seconds to 1/2 second. If the wagons themselves set the points a minimum expenditure of time is arrived at. This led to the idea of using a « switch movement collector » which would arrange in advance the positions of the points to suit the make-up of any train about to be sorted, so that the point operator had, when working on this system only to watch the running of the wagons. In automatic sorting installations [16], the points are no longer set individually, but for routes or parts thereof, in advance and in accordance with « cut sheets » made out for all wagons or cuts composing a train.

With this object in view, the operation of handling the points is no longer carried out at an extended frame. The sidings layout is reproduced schematically on a small table and the points are indicated by switches (fig. 21).

By depressing keys and press buttons and simultaneously moving a lever that is also arranged on the table, the roads are stored in an electric collector drum. The pointsman can thereafter follow the movements of the wagons in peace. Red lamps on the table indicate the passage of the wagons through the points and white lights behind the point switches, show the setting of the points. A re-arrangement of the roads, or the suppression of a pre-arranged run, is at any time possible without interfering with any further runs. Partly on account of expense and partly to maintain the watchfulness of the operator, the last points are not mechanised, but it has emerged that with a proper road layout, at least 80 % of the sorting operations are made within the first points. It has therefore been found possible to work at a speed of 5 feet per second or, in other words, to push off 10 wagons per minute. The third requirement is

Cutting down the intervals.

This requirement has at least the same importance as the other two. Intervals naturally occur at all points where changes or interruptions of the progress of the work are required. In part, the

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(16) H. Diehl, *Verkehrstechnische Woche*, vol. 23 (1929), p. 154.

previously described machines and arrangements operate for reduction, but a working organisation on a proper basis is of the greatest importance. The importance of intervals at the inlet roads and at the run-off are at once apparent. Endeavour must be made to have the cuts from the train follow one another as closely as possible, as that makes for the greatest economy. One should not, for instance always have two pushing engines at work at the hump, but only in so far as will ensure a continual flow of work and obviate intermittent stoppages in the work.

In the case of a hump yard where only one pusher is employed, it is necessary, after one train has been sorted, to run back, pass through many sets of points, pick up the next train and push

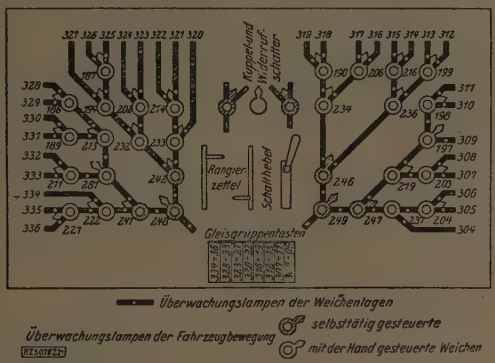

Fig. 21. —Control table, from which the points are electrically controlled at a distance.

Explanation of German terms:

Gleisgruppentasten = Road group keys. — Kuppel- und Widerrufschalter = Coupling and cancelling switch. — Rangierzettel = Cut sheet. — Schalthebel = Switch lever. — Selbsttätiggesteuerte, mit der Hand gesteurte Weichen = Automatically operated, hand operated points. — Überwachungslampen der Fahrzeugbewegung = Indicating lamps for mouvement of vehicles. — Überwachungslampen der Weichenlagen = Indicating lamps for point position.

it forward to the breaking up point, a process occupying from 8 to 15 minutes. In the case of a level yard with an arrival group ramp, from 4 to 8 minutes are required. With an incline yard, the interval is only about 1 minute. The intervals therefore vary between 1 and 15 minutes. At feeding speeds of 1.6 to 5 feet per second, the intervals work out the more unfavourably as the speeds increase. With small intervals, the influence of any change of speed is very considerable. The pushing-off speed has thus a fixed maximum value beyond which the gain in sorting time becomes increasingly less (17). The longer the train the less the importance of the interval. With long intervals again, the difference in the length of trains is of greater influence than with small intervals. When at all possible, therefore, one should try not to have the whole run-off scattered over the whole day but rather to co-ordinate it and to arrange the run-

(17) FROHNE, *Organ für die Fortschritte des Eisenbahnwesens*, vol. 64 (1927), p. 238.

off in shifts so as to reduce working costs. It is desirable to sort long trains, in regular sequence, at not too high a speed because very high speed of run-off does not compensate for increased cost.

The fitting out of yards with all these appliances will not lead to results if the whole yard plan, profile, and point layout are not arranged on a scientific basis. The design of the layout of the incline for use in existing or in new yards depends on existing conditions and requirements. Furthermore, the arrangement of the roads is of capital importance. A selection, abolition and combination of yards must result. Further it is desirable, when possible, to arrange the train times of in- and out-going trains, at regular intervals over the whole day.

From these considerations, it emerges that mechanisation and simplification of marshalling work calls for an accurate and careful investigation in the case of each individual yard. The objects is to improve the turn-round of the wagon stock, i. e. to increase the daily travelling time and decrease the idle time. By these means a fuller utilisation of the wagon stock will be made possible and there will be no necessity to increase the stock to meet an increase in trafic and in the case of a drop in traffic a smaller stock will suffice.

As the result of the introduction by the German Railways, of scientific operation, an accurate watch is kept on all yards. Unfortunately the financial position of the Reichsbahn is such that mechanisation cannot be carried as far as is desirable. The preliminaries are however, so far advanced, that with a favourable money market, it will be possible to undertake thorough mechanisation and rationalisation.

[656. 253 (.42)]

The Strowger-Hudd system of automatic train control.

(*The Railway Gazette.*)

The system of automatic train control, of which the 1927-30 Automatic Train Control Committee reported, under date 3 November 1930, that it had very recently been submitted to them, was, the report said, of a type different from those upon which the Committee passed judgment. It apparently appealed to the members, as the locomotive carried no electrical apparatus of any kind. They therefore made the suggestion referred to above that is should be tried under working conditions, and the report added that the Southern Railway had agreed to do so.

The first installation was laid down

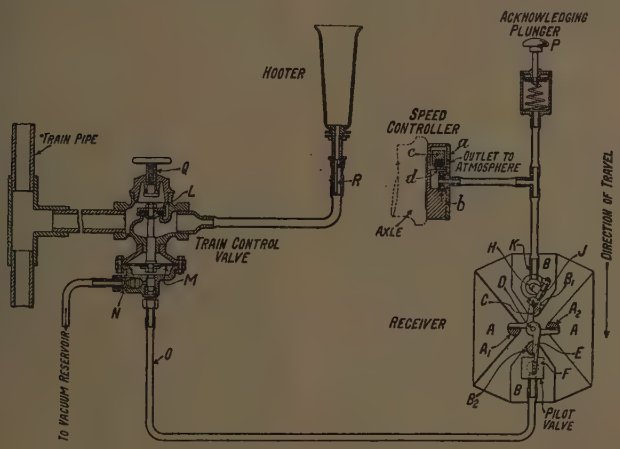

Fig. 1. — Details of Strowger-Hudd speed control equipment suitable for locomotive with vacuum brake.

at Wraysbury on the Staines and Windsor branch, over which line, it is important to note, electrically-operated trains, driven by power derived from a third rail, had been running since the previous July. The first locomotive employed was a tank engine and, further, conditions where against the high speeds that would have to be provided for in mainline working, and therefore it was decided to lay down an installation on the up through line at Byfleet and to equip a tender engine. The locomotive then selected was of the 4-6-0 type, No. 774, *Sir Gaheris*, of the « King Arthur » class, and it has been engaged in general passenger traffic, with the apparatus in full working condition, since March last. Speeds

of up to 78 m. p. h. have been made, with complete immunity at all times from the effects of vibration and shock.

The object attained by the system is that, when a driver is 200 feet from a distant signal, he is warned that he is approaching it by the sounding of a hooter in his cab. That tells him to look out for the signal, but if, owing to fog, he cannot see it, he will wait for a second or two for the hooter to cease. If it does he will know that the distant is at « clear » and will continue on his journey. Should, however, the distant signal be against him, the hooter will continue to sound and the brakes be applied. The driver in that event will shut off steam, cancel the automatic warning of the hooter by operating a release or acknowledging plunger, get his train under control, and proceed cautiously to the home signal. Should that signal be at « danger », the hooter again is sounded and the brakes applied; if the signal is at « clear », there is no blast nor brake application and the driver knows that he may proceed. It should be remarked that the short blast at the approach warning is accompanied by a slight reduction of the vacuum in the train pipe. That, though, is not sufficient to set the brakes, but acts as an intimation to the driver that the brake equipment is working correctly.

One of our protographic illustrations gives a view of the front of the locomotive, showing the necessary equipment in position. It is, as seen, carried on an attachment made to the lifeguards and consists of the four collector plates, A A, B B, with their respective pole pieces A_1, A_2, B_1, B_2, seen in the drawing. Pivoted at D is the armature C, having a spring blade E, that covers the pilot valve F, in the rubber hose connection O to the train-control valve. The armature, normally, has two arms in close proximity to pole pieces B_1, B_2, and the other two arms away from A_1, A_2.

The train control valve is fixed just above the receiver and attached to the train pipe. It has a valve L which normally is held on its seat by diaphragm M, behind which is a constant vacuum from the vacuum reservoir on the locomotive, through a restricted orifice N. When the valve L is released, as will be related later, a portion of the incoming air operates the reed R of the hooter in the locomotive cab and the remainder enters the train pipe and makes a gradual application of the brake.

The receiver on the locomotive is influenced by an intermittent inductive control system, and, it should be noted, there are no contacts and no moving parts. The track equipment consists of inductors, of which there are usually three types. As seen in the accompanying diagram of the track apparatus at Byfleet (fig. 7), there is an inductor A, 200 feet in the rear of the distant signal, which acts as a warning to the driver that he is approaching a distant signal; an inductor B at the distant which is energised, when the engine enters on to a short length of track circuit, by a local battery, switched in should the signal arm be at « clear », but not energised if the arm indicates « warning »; an inductor C at the home signal, which is similarly energised or remains de-energised according to the indication given by that signal. A, being for a warning indication, is constant and uninfluenced by the conditions of the signals.

The inductors differ in construction. We give views of the underside of each, and in figure 3 inductor A is seen in the foreground in the rear of Byfleet up through line distant signal, and, in figure 8, inductor B is shown in position on the track. Inductor B is an electromagnet paralleling the rails. Normally it is de-energised, but, as said above, is energised when the train enters on to the track circuit at the distant signal, provided that the signal arm is at « clear ». Inductor C, as figure 9 shows, is a combination of permanent magnets

and an electro-magnet. If the stop signal is at « danger », the latter is not energised and the permanent magnets alone function; if the arm is at « clear », the electro-magnet, when energised by the train entering on the track circuit at the signal, overcomes the permanent magnets.

Following now the course of a train, it should first be noted that the receiver will be in the condition illustrated in the drawing (fig. 1), *i. e.*, two arms of the commutator C in close proximity to the pole pieces B_1, B_2. As the receiver passes over inductor A, a magnetic field, at right angles to the direction of travel, is thrown up so that plates A, A are energised, the armature C is attracted to pole pieces A_1, A_2, and away from B_1, B_2, and the pilot valve F is opened. The area uncovered is approximately twice the size of the inlet through the orifice N, leading from the vacuum reservoir, and thus the valve L is released. That results in a short blast by the reed R in the hooter in the cab and a slight reduction of vacuum in the train pipe. The latter is, as will be noticed in the next paragraph, not of sufficient duration to

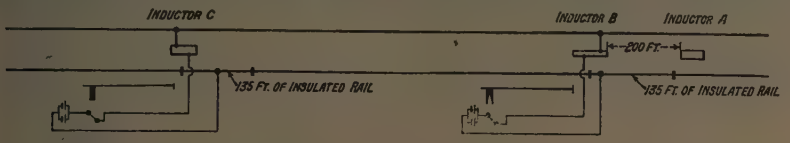

Fig. 2. — Track apparatus as installed near Byfleet, Southern Railway, for Strowger-Hudd speed control demonstration.

affect the brake; its purpose is to warn the driver, also to show that it is working properly.

The locomotive then, almost at once, passes over inductor B. That, as has been shown, is controlled by the indication given by the signal and its magnet is not energised if the signal is in the « warning » position. If the magnet remains de-energised the brakes will then be applied and the hooter continue to sound. If, however, the magnet is energised, the plates B, B pick up the current, the pole pieces B_1, B_2 attract the armature, and the pilot valve is closed so that there is no brake application nor sounding of the hooter.

Should the driver have been warned at the distant, by the sounding of the hooter and the partial brake application, he will proceed cautiously up to the stop signal and inductor C. If that signal indicates « danger », the permanent magnets cause pole pieces A_1, A_2 to again attract the armature and the train control valve to be opened; if, however, the signal indicates « clear », the electro-magnet in C is energised and pole pieces B_1, B_2 hold the armature and prevent the pilot valve from opening.

It will thus be evident that energy is necessary to give a « clear » signal; the absence of energy, *e. g.*, from a failure of the track circuit or of the battery, leads to the operation of the control.

It will be noticed that the schematic diagram (fig. 1) shows an acknowledging plunger P, seen above the hooter in the locomotive cab. It has been provided in order to meet the necessity for the driver to release the brake, after it has been automatically applied at the distant, so that the train may run forward to the home signal; also to stop the hooter. The plunger is connected by a pipe to the diaphragm H, and operates rocker shaft and arm J, so that the armature is restored to its normal position against pole pieces B_1, B_2. To prevent any possibility of continuous operation of the diaphragm H, a small leak hole is provided at K. The plunger is at once

Fig. 3. — Position of inductors « A » and « B », and battery for energising inductor « B » adjacent to Byfleet distant signal.

Fig. 4. — Inductor « C » placed in fast line alongside Byfleet home signal.

Fig. 5. — Arrangement of hooter and acknowledging plunger on driver's side of locomotive cab.

Fig. 6. — Strowger-Hudd automatic train control apparatus on front of locomotive.

reset, when released by the driver, by means of the spring seen below it.

As the question may arise as to how the system operates with colour light signals, seeing that they have no circuit breaker for the track battery to energise the electro-magnet, it should be said that the control circuits for the signals are connected to the inductor, which arrangement has the advantage that the inductor would repeat the condition of the signal section should the signal, for any reason, fail.

Should a distant signal be a colour light signal, with the two aspects of yellow and green, the inductor B would be unaffected should the yellow aspect be displayed and the brake would, therefore, be applied and the hooter sounded. If a green aspect be displayed, the elec-

tro-magnet would be energised and there would be no warning. For a three-aspect signal, showing a red aspect, there would have been the preliminary warning at the distant, and thus the permanent magnets in C would pull the train up. The train would also be pulled up at C should a yellow aspect be given, but in that event the driver could release himself. For a green light at C the electro-magnet in the inductor would overcome the permanent magnets and there would be no check or blast from the hooter.

For a two-arm signal, where there is an upper stop and lower distant, an inductor C would be provided, and if the control was for the stop signal the driver would come to a stand; if for the distant at « warning », he would release himself and run forward to the stop signal that the distant repeated.

In our editorial note on page 327 of

Fig. 7. — Inductor « A », tilted to show underside.

Fig. 8. — Inductor « B », in position.

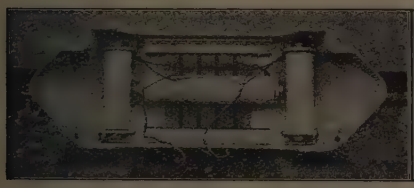

Fig. 9. — Inductor « C », underside.

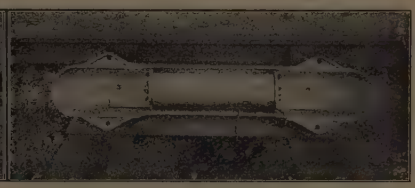

Fig. 10. — Inductor « B », underside.

The Railway Gazette of 21 August 1931, attention was drawn to the evils that were being experienced in train-control systems in the United States from the release of the brake by the irregular use of the acknowledging plunger, and to the intimation from the Bureau of Safety that that practice must cease. To prevent the premature release of the brake in the present system, the Strowger-Hudd arrangement has had added to it — though not as yet at Byfleet — a speed controller *a* running on ball bearings *b*, attached to the axle of, say, the leading wheel of the bogie. When the speed has been reduced to 25 m. p. h., or less, the weighted valve *c* closes the outlet *d*, and allows the acknowledging plunger to be used; at speeds over 25 m. p. h. the valve *c* is kept open by centrifugal force and the operation of the plunger is of no effect.

It will be of interest if it be noted at this point that, having the Carlisle fatal derailment in January 1931 in mind, also those at Weaver Junction, Kent House (1)

(1) See *Bulletin of the Railway Congress*, September 1931, p. 788.

and Beal, to which Colonel Mount drew attention in his report on the accidents of 1930, this addition could be utilised for speed control over curves. In such cases an inductor of the A type, requiring no current, would automatically apply the brakes at a given point, should the speed limit be exceeded, and keep them applied until the train had been brought down to the pre-determined speed.

One other point remains to be noticed. It is common knowledge that one reason why no action was taken on the report of the earlier Automatic Train Control Committee was the difficulties in the way of dealing with the question of clearance between the engine equipment and that on the track, also for engine equipment in relation to the third rail, where used in electric traction, and to the girders on some of the older bridges. That led to certain recommendations by the 1923-27 Committee, and one recommendation was that any equipment on the train should have a full clearance of 4 inches above rail level. In the present arrangement that clearance is 5 inches; there is also a clearance of 4 inches between the bottom of the receiver and the top of the inductor.

Mention, above, of the third rail suggests that it should again be remarked that, as exemplified at Wraysbury, the presence of the third rail does not interfere with the provision of the inductors, nor are the latter affected by the traction current.

The Strowger-Hudd system is the property of Automatic Electric, Inc., of Chicago, but all the apparatus is British made, having been manufactured at the works of the Automatic Telephone Manufacturing Co. Ltd., of Liverpool.

At a meeting of the Locomotive Men's Craft Guild, held at the Borough Polytechnic Institute on Saturday evening, 19 September, when some 100 members were present, Mr. Hudd explained the Strowger-Hudd system, assisted by full-size models and lantern slides. The meeting opened with some remarks by Mr. H. C. Charleton, M. P., who was a member of the second Automatic Train Control Committee and so was able to give his impressions of the trials at Wraysbury and Byfleet. Mr. Hudd followed and at once won the sympathy of his audience by saying that he was an Englishman and a railwayman, and one who always had had admiration for the British engine-drivers. He was, he added, a premium apprentice of Sir John Aspinall, at Horwich, and had charge, under Mr. H. E. O'Brien, of the mains and cables of the Liverpool and Southport electrification, and went thence to Victoria for the electrification of the Melbourne suburban railways. Returning to this country, he got interested in automatic train control and paid several visits to the United States to study the systems in use there.

During the course of his lecture, Mr. Hudd pointed out the benefits of using a vacuum as the means for train control; it was cheap, did not freeze and cleaned itself. He pointed out the boon his system would be to the driver as he would get an intimation of the proximity, and then the condition, of every distant signal, and how, in fog, after receiving a warning at the distant, he could drift down to the stop signal in the assurance that he would be stopped there should the signal be « on ». The security afforded by the system giving a definite stop at home signals was alluded to and how important that feature was at junctions and other more dangerous points. The saving in running time, particularly now that economy in working was so essential, was commented upon, also the fact that fog signalmen — estimated by the first Automatic Train Control Committee to cost £100 000 a year — can be dispensed with. The system, further, is always on duty — by day and night, in foggy weather and clear.

CURRENT PRACTICE.

[621. 138.3 (.42)]

Improvements at Stratford locomotive depot.
Boiler washing plant.

The London and North Eastern Railway have recently installed, at their Stratford locomotive running shed, plant providing improved facilities for hot and cold water washing-out of locomotive boilers. The running shed is the main London depot for the Great Eastern section of the system and the hot-water washing-out plant has been supplied and erected, to the specification of H. N. Gresley Esq., Chief Mechanical Engineer to the Company, by Messrs. The Economical Boiler Washing Company Ltd., London.

In addition to this plant the work undertaken includes rearrangement and improvement of the water supplies; the installation of two stationary locomotive type boilers providing power and heat for the hot water washing-out plant and a booster pump to deliver pressure water for cold water washing-out services.

The hot water washing-out plant is the well-known White's system already fitted at a number of depots on the London and North Eastern Railway system. It has for its object the distribution from a central plant to various points in the shed of three services, one to allow for boiler water to be blown out into the system, one to distribute pressure hot water for the usual washing-out process and a third service of clean hot water for filling locomotive boilers as required. The chief advantages of such a system are firstly the reduction of time over the ordinary cold water process increasing the availability of locomotives and secondly the facility with which boiler water can be changed when desired.

The layout of the plant is shown figure 1. The building containing the main plant is situated between the main running shed and the smaller shed. The hot water services are arranged to be available throughout the twelve roads of the main shed, by six sets of distributing overhead pipe lines positioned intermediately so as to each serve two roads, and containing in every line nine triple drop connections spaced 45 feet apart. The smaller shed is served by two lines serving three roads and each line has five triple drop connections similary spaced. The central plant is arranged on the double tank system and is sufficient to handle six locomotives under each of the three different services — that is six can be blown down, six washed out and six filled at any one time. Thus it can be normally said that the plant handles six locomotives on any of the possible phases of the hot water washing-out process. The plant is thus the largest installation in the country. This size was determined on the basis of a 24-hour day and its great capacity was decided on to cope with the very large number of engines stationed at this depot. The heavy traffic makes it most desirable that engines should be available promptly and give a maximum earning capacity.

The central plant is housed in a brick building conveniently placed for its duty. There are two cylindrical hot water tanks of 15 000 and 20 000 gallons

capacity which act as reservoirs for the washing-out and for the filling water respectively. Water from these tanks is delivered under a pressure of 60 lb. per square inch to the pipe lines by two horizontal duplex compound Worthington steam pumps, one connected to each tank. Water blown back from locomotives is treated in the following way : The blow-out pipe line enters a separator (or filter) and the water first strikes a baffle breaking it into a spray. Steam evaporated from the water on reduction of pressure is led away and utilised in

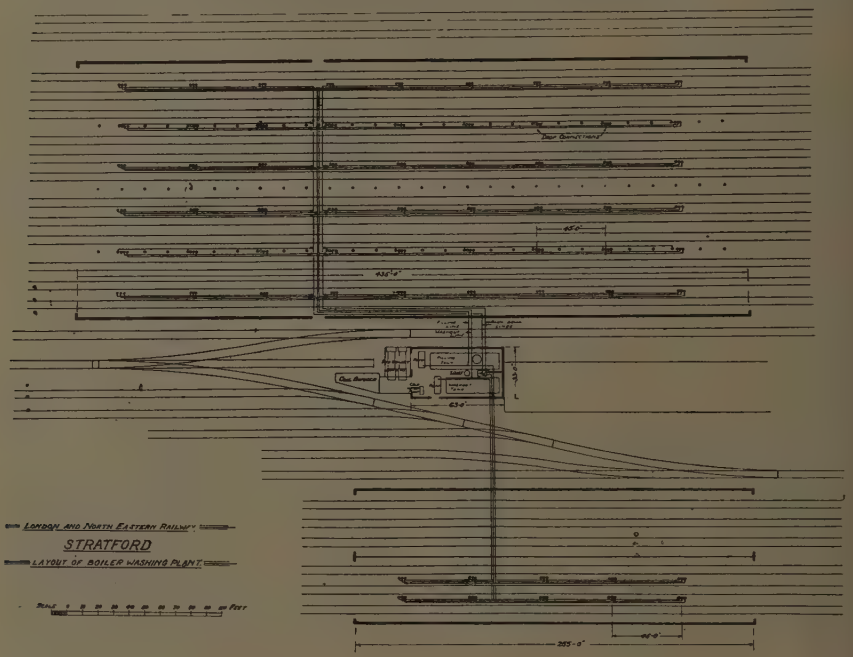

Fig. 1.

the heater by condensation and feeds into the filling tank. The remaining blown down water passes through the filter containing broken coke to the wash-out tank. Sediment drains into a sludge tank which is blown to waste as required. The level in each tank is maintained by automatically controlled valves. Two locomotive type stationary boilers are set adjacent to the tankhouse one being in use and the other spare. Their function is to provide steam at a pressure of 100 lb. per square inch for the two pumps and to act as an auxiliary source of heat for the main tanks. The whole of the exhaust steam from the pumps passes into the tanks. Both exhausts can be concentrated on one tank if necessary.

The triple services mentioned are distributed by three overhead mains serving the small shed and by four mains

serving the main shed. In the latter case the blow-out main is divided. From each drop connection on the wash-out and filling services, near the individual control valves, a small diameter pipe connects to a small return main to the tanks ensuring a complete circulation of hot water to every working point and maintaining the temperature. The two steam pumps when no work is being done are running light at a slow speed maintaining a pressure of 60 lb. per square inch and a slow circulation of water. The opening of any valve in the

Fig. 2.

shed on the wash-out or filling lines temporarily releases the pressure in the mains and brings into operation the regulator of the pump concerned, governing the steam admission valve. The pump then takes up the load until the valve concerned is shut, when the regulator closes to its former position and the pump slows down again. Both regulators are set to maintain a pressure of 60 lb. per square inch in the mains and each pump is of a sufficient capacity to maintain this pressure with a delivery of 30 000 gallons per hour. In case of emergency it is arranged that each pump can pump from either tank and supply both services.

The working temperature of the water

is maintained within predetermined limits and they have been fixed as high as is practical in the circumstances. The maximum temperature of the wash-out water used on this plant is 180° F. and that of the filling water is 210° F. The temperatures are automatically limited by thermostatically controlled valves. In the case of the wash-out water the thermostat is placed in the pump delivery and is set so that should the temperature rise above 180° F., a normally

Fig. 3.

closed diaphragm valve admits cold water to the pump suction, adjusting the temperature of the actual water delivered, whilst retaining the temperature of the tank water. The prescribed temperature limit for the filling water is obtained by placing a thermostat in the filling tank which is connected to a normally open diaphragm valve admitting live steam to the tank until the temperature reaches 210° F., when the thermostat comes into operation and closes the valve. These thermostats can be adjusted to suit requirements. The pump regulation previously mentioned and the temperature control described enable the plant to work automatically.

The tank house also contains a 13-H. P.

motor-driven centrifugal pump supplying the cold water washing-out service. This unit has a capacity of 13 200 gallons per hour when pumping against a pressure of 43 lb. per square inch. The original washing-out mains have, with certain alterations, been used for this service. This pump obtains its supply from the mains at a positive pressure, and a bye-pass has been arranged for use in emergency so that washing out can still take place during a breakdown of the pump.

Fig. 4.

At the same time as this work was undertaken rearrangements were made to the water supplies. Originally water from several sources was mixed in the service reservoir located close to the Stratford running sheds and having a capacity of 110 000 gallons. The pressure of water available for any purpose was strictly limited to about 13 lb. per square inch. The service to this tank was formerly interconnected with the general water supply of the locomotive works adjacent, which is derived partly from two wells and partly from the Metropolitan Water Board mains. The well waters are of inferior quality. Town water only is now fed to the tank and thence to the water cranes and the hot

water washing-out plant and it is now the only water used for filling locomotives. A new 8-inch town water main has been laid to the service tank, ensuring an adequate supply of water at all times for every purpose. The mixed water has been separated and is used for both cold and hot washing-out purposes, but if emergency arises the other source can, in addition, be drawn upon. The Stratford locomotive sheds have now a full supply of water at adequate pressure for all purposes and sufficient for all contingencies.

For the successful operation of this hot-water washing plant it is necessary for locomotives, after the fire is dropped, to come into the shed with a steam pressure of at least 40 lb. per square inch and blow down with as little delay as possible. If this is done the greater part of the heat in the boiler water is recovered. The time occupied is about half an hour and the operation exercises a considerable cooling influence on the boiler so that hot washing out can be started immediately. Connection is made to the drop connections by a length of 2-inch armoured hose pipe with unions which are suitable for fixing to the various hydrants. The time taken for the whole operation of blowing down, washing out, refilling and steaming varies with the size of the locomotive. For a large engine of the Sandringham class (4-6-0), this is a minimum of six hours which compares very favourably with the twelve hours under the previous low-pressure cold-water method.

Savings that are made possible under this scheme deriving principally from the Economical Boiler Washing Company's plant are availability of engines, fuel for lighting up and a distinct improvement in the internal condition of the boilers with its contingent advantages. A saving of water is made as the water in the locomotive boiler is filtered and used again for washing out purposes, and also as the make-up water used is inferior water, which, while not being suitable for boiler feed, is satisfactory for washing out.

[621 .134 .1 (.42)]

London North Eastern Railway re-built 4-4-2 type express passenger locomotives fitted with booster.

Two of the C. 7 type 4-4-2 express passenger engines, Nos. 727 and 2171, of the original North Eastern Railway, built respectively in 1911 and 1913, having three single-expansion cylinders, driving the first pair of coupled wheels, have been re-built and fitted with boosters. The booster is fitted to a bogie placed behind the coupled wheels under the cab. This is the first example of articulation between an engine and a tender in which the rear end of the engine and the front end of the tender are carried on a common bogie. The arrangement has greatly improved the riding of the engine and eliminated the relative lateral movement between the engine and the tender.

The booster bogie has a side play of 4 1/2 inches each side, controlled by a pair of coil springs, having an initial compression of 2 tons.

A boiler of new design has been fitted having a sloping throat and back plate and a larger firebox. The boiler pressure has been increased from 175 lb. to 200 lb. per square inch.

Operation of booster.

The booster, which was manufactured by Messrs. J. Stone & Co. Ltd., Deptford, drives the front axle of the booster bogie, and is spring suspended. A gear ratio 1 : 1 enables the booster to give out useful work up to speeds of 30 miles per hour, and also facilitates engagement of gears.

The booster is steam-controlled and can be cut in at any speed up to 30 miles per hour. The sequence of operation, shown on diagrammatical view, figure 3, is as follows :

When Boiler Steam Cock No. 1 is opened, it allows steam to pass through pipe *1* to the Reverse Lever Pilot Valve No. 2 and to Clutch Safety Piston Control Valve No. 34. The steam unseats Valve No. 35 allowing steam to pass through pipe *12* to Clutch Safety Piston Cylinder No. 36, thus preventing Idler Gear No. 14 accidentally rocking over and damaging gears. The Boiler Steam Cock No. 37, when opened, allows steam to flow through pipe *13* to Preliminary Throttle Valve No. 6, seating Valve No. 8. Main Throttle Valve Cock No. 43 is opened, and Booster is now ready for operation.

To operate Booster, depress Reverse Lever Pilot Valve No. 2 by raising Booster Latch No. 3; this unseats Valve No. 4 and seats Valve No. 5, and allows the steam to flow through pipe 2 to Clutch Safety Piston Control Valve No. 34. This moves the Piston No. 38 in the direction of arrow, which seats Valve No. 35, thus cutting off steam to Clutch Safety Piston No. 36 and leaving the gears free to rock about the Centre No. 13. The steam in pipe 2 flows on to Preliminary Throttle Valve No. 6 and on to Clutch Cylinder No. 7 through pipe *3*. The steam entering the cylinder of the Preliminary Throttle Valve No. 6 causes the piston to move in the direction of arrow and opens Valve No. 8, thus allowing the steam to pass into pipe *4* through Choke No. 9 to the Booster Main Steam Pipe *5*. The Choke No. 9 controls the quantity of steam, allowing sufficient for turning the Booster over Slowly.

Fig. 1.

Fig. 2.

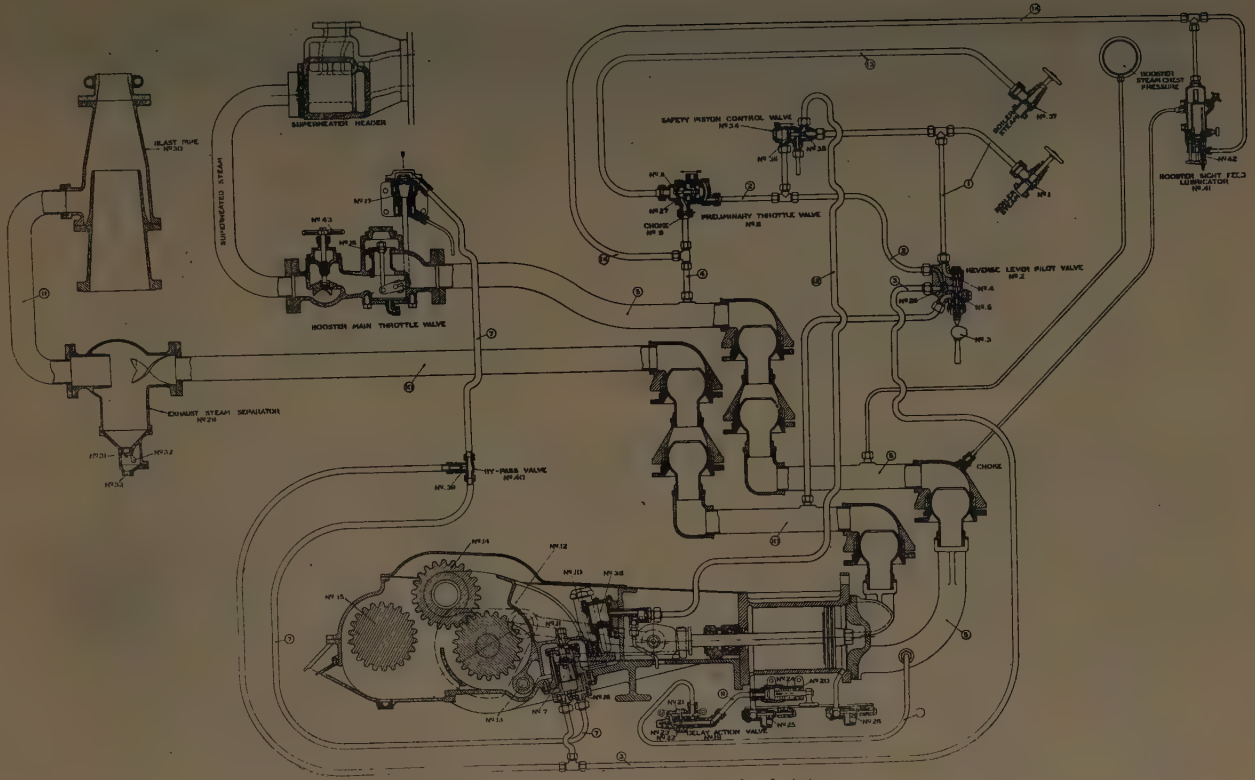

Fig. 3. — Steam control diagram for booster.

While the foregoing is taking place, the steam is passing through pipe *3* to the Clutch Cylinder No. 7 and causing the Clutch Cylinder Piston to move in direction of arrow, compressing Spring No. 10 and by means of Pin No. 11 moves Idler Gear Rocker No. 12 on Fulcrum No. 13, so that Idler Gear No. 14 meshes with Axle Gear No. 15. When the Clutch Cylinder Piston has completed its movement, it uncovers Port No. 16 and allows the steam to pass into Pipe 7, Seating Ball No. 39 in By-Pass Valve No. 40, and thence to Booster Main Throttle Valve Operating Cylinder No. 17, and causes its piston to move in direction of arrow, thus opening the Booster Main Throttle Valve No. 18 and allowing the full steam pressure to be admitted from Locomotive Header to Booster Main Steam Pipe *5*.

When the steam pressure is built up in the Booster Main Steam Pipe *5*, the steam through pipe *8* enters the Delay Action Valve No. 19 which controls the Cylinder Relief Cock Operating Cylinder No. 20. The steam on entering the Delay Action Valve No. 19 causes the Piston No. 21 to close the Exhaust Valve No. 22; the steam then passes slowly through Needle Valve No. 23 and then through pipe *9* and builds up slowly behind the Piston of the Relief Cock Operating Cylinder No. 20. When sufficient pressure has been built up to overcome the resistance of spring No. 24, the Piston moves in the direction of arrow, and allows the steam in the Booster Cylinder to automatically shut off the Cylinder Drain Cocks Nos. 25 and 26.

A small hole No. 27 is introduced in Preliminary Throttle Valve No. 6; this is to permit a certain amount of steam being continuously fed to the Booster Cylinders in order to keep them warm.

To idle the Booster, the Idling Valve No. 28, shown in the Reverse Lever Pilot Valve No. 2, is turned so that the passage connects with the pipe *1* and allows the steam to flow direct to pipe 2 leading to the Preliminary Throttle Valve and shutting it off from pipe *3* leading to Clutch Cylinder No. 7.

The exhaust from the Booster is taken through pipe *10* to the steam separator No. 29 and thence through pipe *11* into an annular space in Blast Pipe No. 30 and to atmosphere in the ordinary way. Valve No. 31 in the Steam Separator No. 29, which is balanced by counterweight No. 32, is operated by the weight of trapped moisture in chamber, the moisture being allowed to drain through the Opening No. 33. The by-pass Valve No. 40 is provided as an auxiliary exhaust from Booster Main Throttle Valve Operating Cylinder.

The Booster Cylinder Sight Feed Lubricator No. 41 is automatically started by steam from pipe *4* passing along pipe *14* from Preliminary Throttle Valve, and is provided with an anti-syphoning Device No. 42 which breaks the syphoning action when steam is cut off by Preliminary Throttle Valve.

* * *

Due to increased boiler pressure, the tractive power of the engine has been increased from 19 300 lb. to 22 012 lb. or a total, with booster, of 27 012 lb.

During recent tests with engine No. 727 on a 300-ton train a speed of 18 m. p. h. was obtained in 8 minutes on a gradient of 1 in 70 with the booster out of operation.

With the booster in operation, a speed of 25 m. p. h. was reached in 5 3/4 minutes.

On a level road the engine, with the booster out of operation, was able to start a load of 496 tons, the drawbar pull being 9 tons. With the assistance of the booster, a load of 746 tons was started with a drawbar pull of 12 1/4 tons.

MISCELLANEOUS INFORMATION.

[625. 143 (.73)]

1. — New 152-lb. flat bottomed rails, Pennsylvania Railroad,

by T. J. SKILLMAN,
Chief Engineer, The Pennsylvania Railroad.

(*The Railway Gazette*).

The Pennsylvania Railroad has in 1931 put into service a new standard rail section for heavy duty use, weighing 152 lb. a yard. The first heats were rolled and placed in the track in May and June, 1931. The rails are 39 feet long. Aside from its technical significance, the production of this rail, the heaviest and strongest ever manufactured for regular service on any railroad, constituted an event of much historic interest as it signalised the rounding out of an even century of progress in the evolution of the T-rail. Further interest attaches to the fact that the original T-rail was the invention of a celebrated engineer who designed it for use on what is now a portion of the Pennsylvania Railroad system.

On 16 May 1831, there arrived in Philadelphia, from England, the first T-rails ever produced. They weighed 36 lb. to the yard, were 3 1/2 inches in height and 3 1/4 inches at the base. They were of rolled iron, and were for the track of the Camden & South Amboy Railroad, projected to run from Camden, N. J., on the Delaware River, opposite Philadelphia, to South Amboy, N. J., on the Raritan River. This line is in operation today as part of the New York Division of the Pennsylvania Railroad. Its first President and Engineer, Robert L. Stevens, designed the rail and invented the principle of the T section. The fundamentals of his design have been retained to the present day, and the T section remains the standard type of rail in most countries. Its influence was particularly important in the United States, where a primary requirement for the opening up and development of a new and debtor country was a rail answering fully the needs of service and at the same time capable of being produced and laid at reasonable cost.

The trend of modern railroading is toward increased capacity and lading for freight cars, increased weight of passenger equipment, increased length of trains in both branches of the service, and steadily advancing speeds. The influence of these factors is likely to grow rather than diminish in the future.

Conditions to be met.

Owing to the difficulty of maintaining existing permanent way to withstand such conditions, committees were formed of representatives of the United States Steel Corporation, the Bethlehem Steel Corporation, and the Pennsylvania Railroad. These committees made thorough reviews and analyses of the problem, and set for their aim a rail design that would accommodate safely and satisfactorily 100 000-lb. axle loads at a speed of 100 miles an hour. These requirements compare with 80 000-lb. axle loads at speeds of 80 miles an hour, applicable to the 130-lb. main line standard rail section heretofore in use on the Pennsylvania Railroad. It was concluded that this increased allowance for axle loads and speed would take care of the transportation developments of the next 25 years.

The chemical composition and desirable arithmetical attributes, as to stiffness and strength, were fixed, and the design made accordingly, in order to fit as nearly to these attributes as possible. Calculations were made indicating the stresses to be obtained from a purely theoretical standpoint. The result was to demonstrate the necessity for a rail section in which would be incorporated, among others, the following features, namely :

1. A height of approximately 8 inches, or 1 3/8 inches higher than the 130-lb. section

Fig. 1. — Stages in the development of steel rails on the Pennsylvania Railroad, from the original 56-lb. T-rail to the present 131-lb. rail.

heretofore standard, as an important element in increasing the stiffness of the rail.

2. A head designed with as flat a radius as would be praticable to manufacture, in order to give broad contact with the wheel tread.

3. A definite desirable ratio of the perimeter of each portion of the rail, that is the head, the web and the base, to their respective volumes, in order that the rate of cooling should be as nearly even as possible to minimise the setting up of internal stresses in the process.

4. That the rail should be canted in the ratio of 1 to 40, by use of a canted tie plate, as a further means of providing better contact between the head of the rail and the wheel tread.

The working out of these requirements produced a section weighing 152 lb. to the yard, and possessing 75 % greater stiffness than the previous 130-lb. section.

In determining the surface of the head, in order to have the surface stresses initially as low as possible, the contours of the wheel treads on many cars in active service were studied and an average made. As a result, it was found that a 24-inch radius for the surface of the railhead would be the nearest fit to the average contour that would be practicable to roll. Observation, so far, of the behaviour of this rail in the track has indicated that the contact between the rail and wheel has been materially extended, and the object sought has therefore been attained.

As a result of the knowledge gained in designing the new 152-lb. section, the 130-lb. section has been revised to accord with the principles of the new design. The result has been to add 22 % to the stiffness of the rail, with an increase of only 1 lb. per yard in weight. The new 131-lb. section will hereafter be the standard on main line track, except where extraordinary conditions of traffic require the 152-lb. section. The latter is now being laid at various points between New York and Pittsburgh, and its use on the main east and west and north and south stems of the system will be progressively extended, to replace existing rail, as conditions of traffic and wear warrant.

New design of fishplate.

The greater fishing space provided in the higher web of the new rails has made it possible to design a simpler but more effective form of fishplate (or splice bar), which results in a much improved rail joint. In particular, features of design have been introduced which produce greater vertical stiffness, as well as lateral resiliency. The latter makes it possible to take up the wear and tear that occurs between the underside of the head of rail and the top of the fishplate.

Fig. 2. — Sections of original iron rail used on Camden and Amboy Railroad, 1831, and 152-lb. rail for Pennsylvania Railroad, 1931.

It may be appropriate to append to this brief description of the new rails a reference to the fact that the Pennsylvania Railroad was the first American system to adopt steel rails. The production of steel rails, as is widely known, was made a commercial possibility by the perfecting of the Bessemer process and the great cheapening in the cost of making steel which followed.

In 1862, John Edgar Thomson, then President of the Pennsylvania Railroad, made a study of the production of steel rails in England, where they were being placed on the market for the first time. Impressed with their advantages, he decided to purchase 400 tons for experimental use. They were placed in the track for test purposes between Altoona and Pittsburgh. The weight of these rails was 56 lb. to the yard. The results of the tests were so favourable that the management decided to adopt steel rails as the standard for subsequent purchases. The 130-lb. section, which has just been superseded for standard Pennsylvania Railroad main-line use by the new 152-lb. and 131-lb. sections, was adopted in 1916. It was a modification of and improvement upon a 125-lb. section adopted in 1914. Prior to that, the standard main-line rail of the Pennsylvania Railroad had been a 100-lb. section since the early '90's, and various lighter sections were in use in earlier years.

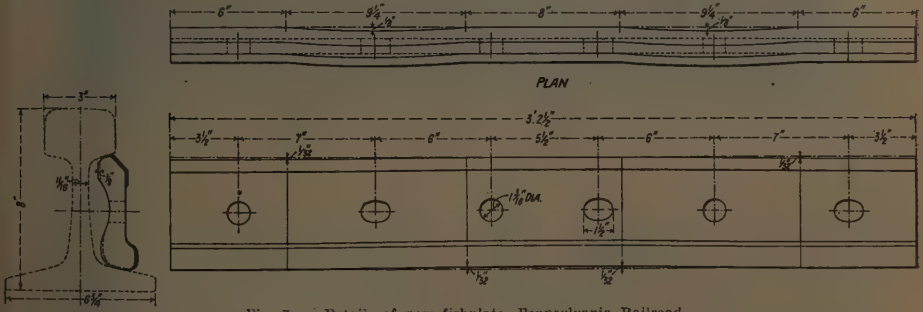

Fig. 3. — Details of new fishplate, Pennsylvania Railroad.

[621. 43 (.43)]

2. — Rail omnibuses on the German Railways.

(Railway Gazette.)

The use of rail motors and motor coaches of various types has considerably increased in most countries during recent years as a means of cheapening operation on subsidiary lines, while providing a more frequent and rapid service than would be economically possible with heavy trains. As its name implies, the Henschel rail omnibus is a vehicle running on rails but offering accommodation and service similar to those of a road omnibus. It provides cheap and rapid transport for passenger and light goods in local services on main, as well as on branch, lines. The reduced operating costs and improved service offered combine to form an effective means of meeting the competition of road transport, and of regaining and stimulating traffic.

Distinctive features.

Compared with ordinary rail motors, the rail omnibus has the advantages of less weight,

Fig. 1. — General view of Henschel rail-omnibus.

higher acceleration, lower capital cost, and more economical operation. The makers have had wide experience in the building of lorries and omnibuses for road service, as well as railway vehicles, and the new rail omnibuses represent an interesting combination of features from both road and rail practice. Thus, the frame of the rail omnibus is strong but simple and without draw gear and buffers, no trailers being used. There is, however, a bumper bar at each end of the coach with a drop coupling for use in emergencies. Propulsion is by means of an internal-combustion engine of the automobile type, with high overload capacity, low range of engine speeds, and economical fuel consumption. The wheels are fitted with reinforced discs in order to secure smoother running, and, for the same reason, long, flexible springs are used with rubber stops to absorb shock. The power unit is arranged at one end of the frame to facilitate erection and dismantling, and a driver's cab is provided at one or both ends as required. The controls are simple; very little is needed

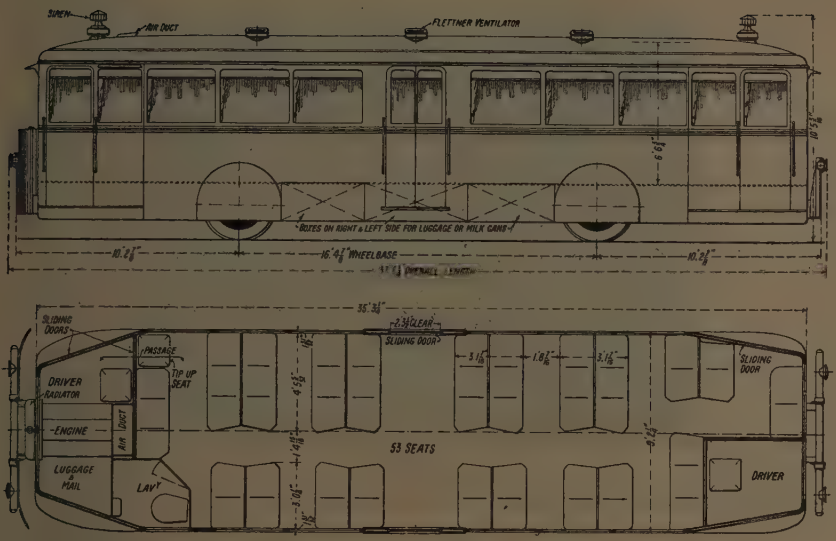
SIREN
AIR DUCT
FLETTNER VENTILATOR
BOXES ON RIGHT & LEFT SIDE FOR LUGGAGE OR MILK CANS
10'2⅞"
16'4½" WHEELBASE
10'2⅞"
35'3¼"
SLIDING DOORS
2'3½" CLEAR SLIDING DOOR
PASSAGE
TIP UP SEAT
DRIVER
RADIATOR
ENGINE
AIR DUCT
LUGGAGE & MAIL
LAV'Y
53 SEATS
SLIDING DOOR
DRIVER

Fig. 2.

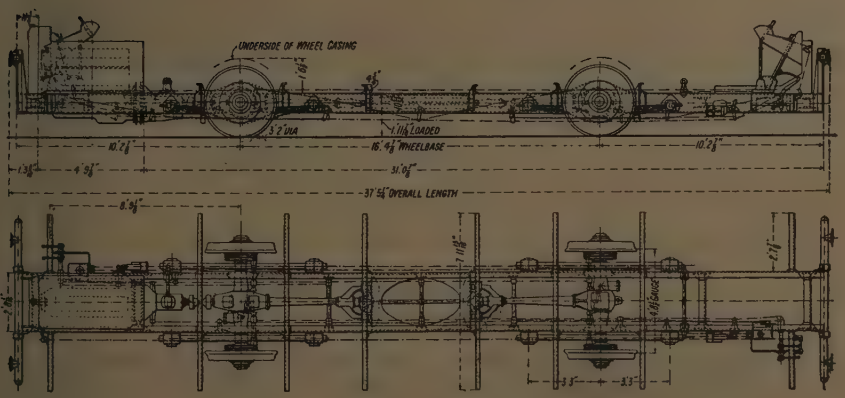
UNDERSIDE OF WHEEL CASING
5'2" DIA
1'11½" LOADED
10'2⅞"
16'4½" WHEELBASE
10'2⅞"
31'0⅝"
37'5¼" OVERALL LENGTH

Fig. 3.

in the way of maintenance, and the replacement of the standardised components can be effected quickly and at minimum expense.

Technical details.

According to requirements, four- or six-cylinder engines are used. A multiple-plate dry clutch is employed, and the change-speed gear provides three forward speeds and one reverse. All four wheels are driven, thus ensuring rapid acceleration. In the omnibuses with a cab at each end, reversal of running is effected by a special device in the transmission shaft, operated by vacuum.

The main frame is a die-stamping of heat-treated nickel-steel plate, and its design secures a low centre of gravity. Neither the upper nor the lower flange of the longitudinal channel girders is drilled, all screw and rivet holes being arranged in two rows in the web. The body rests on and is attached to the cross-stays.

Four brakes are provided. The foot brake is entirely mechanical and acts through expanding shoes. The hand brake is for holding purposes. The third brake is provided by the engine; a displacement of the camshaft closes the admission valves, and the exhaust valves are actuated so as to produce compression for braking on a two-stroke cycle. The engine brake gives smooth retardation and effects considerable saving in brake linings and in fuel. Finally the fourth or emergency brake is actuated automatically by the dead man's handle. On releasing the throttle lever, the ignition is interrupted, the mixture is throttled, and current is cut off from an electromagnet, which thereupon connects the Bosch brake cylinder with the vacuum tank. This brake is also effective when the engine is not running. Sanding gear is provided on all wheels for both directions of running. An electric starting equipment is fitted, as in automobile practice, electric lighting is installed throughout, and electric syrens and bells are employed for signalling.

Accommodation can be provided for up to 90 persons, the number and arrangement of seats, and the proportion of standing space being varied to suit individual requirements. The body, seats, doors, and windows, as well as the heating, ventilating and lighting equipment, follow established road omnibus practice, and standardised components are used throughout. The weight of the vehicle for standard-gauge track is about 10 tons 15 cwt., but varies somewhat with the details of the fittings. Normally, the maximum speed is about 70 km. (43 1/2 miles) an hour, but vehicles can be built for other speeds and gauges as required. Using a mixture of two-thirds petrol with one-third benzol, the fuel consumption of the rail omnibus running on main-line track with normal gradients averages about 36 l. per 100 km. (about 7 3/4 miles to the gallon). The consumption of lubricating oil is about 0.75 kgr. per 100 km. (approximately 300 miles to the gallon). With a wheelbase of 5 000 mm. (16 ft. 5 in.), gradients of 1 in 50, with a minimum radius of 220 m. (722 ft.), can be negotiated at about 35 km. (22 miles) an hour on direct drive.

Figure 2 shows the general arrangement of the body for a 53-seater Henschel rail omnibus with driver's cab at each end, while the general arrangement of the underframe, engine and transmission gear is shown in figure 3.

[621. 134.5 (.73) [

3. — The Edna mechanical lubricating system.

(Railway Age.)

A universal heavy-lubricant mechanical lubricating system for locomotives involving the use of the Edna forced-feed lubricator and special fittings is one of the recent developments of the Edna Brass Manufacturing Company, Cincinnati, Ohio. This company has manufactured forced-feed lubricators for several years and originally the lubricator described in this article, which forms a part of the entire lubricating system, was designed to distribute

valve oil to valves, cylinders, air pumps, feedwater-heater pumps, stoker and booster engines and other steam-operated parts. Later, extending the resarch work into the general field of locomotive lubrication it was found that this lubricator was capable of handling a much heavier lubricant such as is most suitable for driving-wheel hubs, shoes and

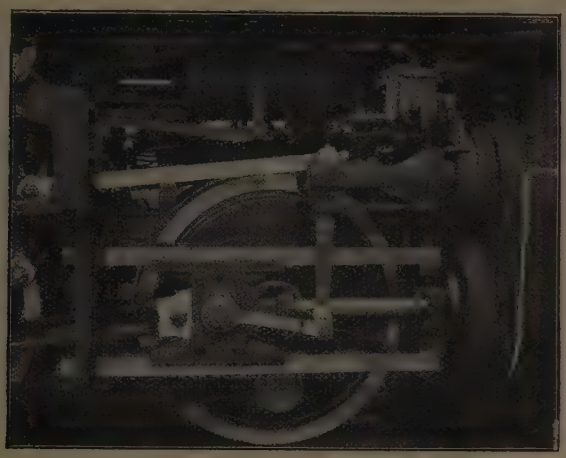

Fig. 1. — Edna mechanical lubricator mounted on the right-side of a locomotive, showing connections to top and bottom guides and operating mechanism attached to the combination lever.

wedges, bearings, guides, flanges, chafing iron, expansion pads and other frictional and moving parts of a locomotive.

The mechanical lubricator, which is the heart of the entire system, is mounted on the locomotive in such a manner that it may

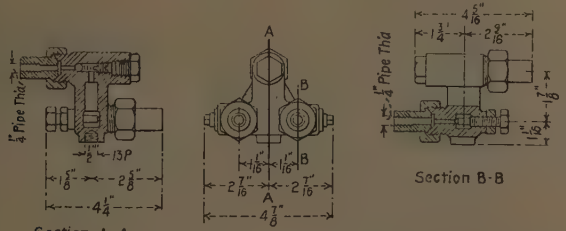

Fig. 2. — Distributing manifold and terminal showing check and regulating valves.

derive its motion for operation from the combination lever or other suitable valve-motion part. The latest model lubricator, known as the model 1930-Duplex, is a combination lubricator having an oil-tight partition dividing the body into two compartments, each containing a different grade of lubricant. From the compartment containing valve oil the cylinders, valves and steam appliances are oiled while from the other compartment a heavier

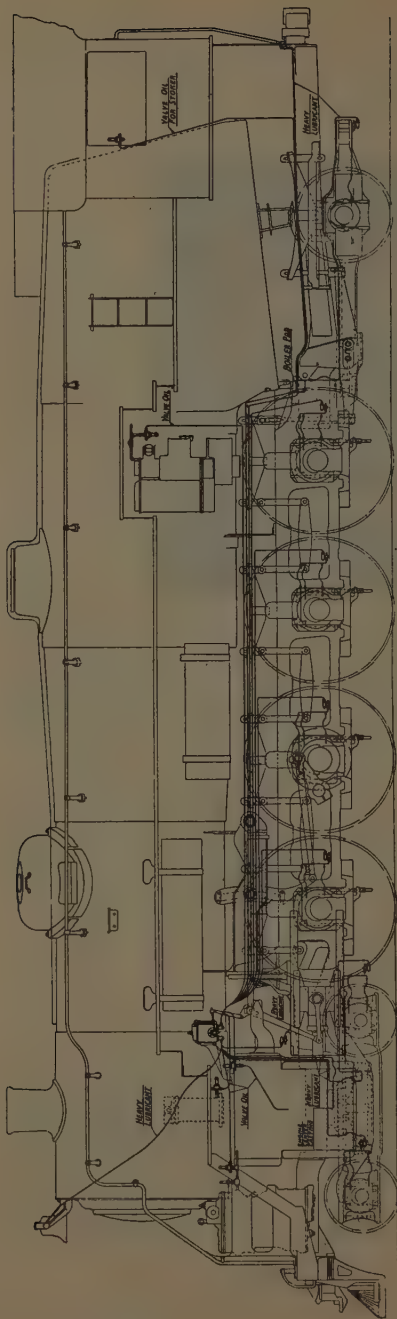

Fig. 3. — Valves, cylinders, air-compressor, feedwater pump, stoker and booster engines are supplied with valve oil, while hubs, shoes, wedges, guides, front-end main-rod bearings and other parts are furnished with a heavy lubricant from a single Edna forced-feed lubricator.

lubricant is delivered to wheel hubs, shoes and wedges, guides, etc. for which a heavier lubricant is more suitable. The model 1930 lubricator, which differs from the previous model 1928 primarily in that it has two compartments instead of one, is manufactured in sizes up to 40 pints capacity, with 16 feeds. All of the moving parts operate in oil and many parts are manufactured from Nitralloy and stainless steel in order to insure long life.

The lubricator is operated by a single power-driven shaft which actuates an eccentric through a ratchet and pawl. For each feed on the lubricator there is a unit containing a plunger, check valve and a forcing valve. The forcing valve obtains its vertical motion from the eccentric. Each unit may be removed independently for repair or replacement and they are so designed that the oil pipes may be disconnected without losing the oil in the lines. Each feed on the lubricator may be adjusted separately by a screw that is conveniently located just inside the cover and above the high level of the oil. The lubricator is provided with a steam heater for use in cold weather and may be mounted on either the right or the left side of the locomotive.

In equipping a locomotive with the complete system of forced-feed lubrication the heavy lubricant is piped from the outlet feeds of the mechanical lubricator to a distributing manifold and terminal which in turn may provide either two, four or six feeds. The inlet to the distributing manifold is through a ball check valve and the outlets from the manifold are through needle regulating valves, the openings of which may be adjusted and set for the desired amount of heavy lubricant. From the distributing manifold the heavy lubricant is carried through flexible connections and pipe fittings to the points where it is required.

The first installation of this type of universal lubricating system was made on a *Santa Fe* type locomotive and went into service on 13 February 1930. At that time the connections from the lubricator were made to the hubs of five pairs of drivers, one pair of engine-truck wheels and one pair of trailer wheels. With the exception of the main driv-

ers, which were dropped in September 1930, for refitting and taking out the box pound, these parts have been lubricated continuously since the original installation and no repair work has been done on any of the bearings. A check of the milage and the wear of the several bearings on subsequent dates in given in the table.

Operating records.

At the time this article was written this locomotive had covered about 75 000 miles. The average mileage between shoppings for wheel and driving-box work for locomotives of the same class and in the same service but without the forced-feed mechanical hub lubrication is said to have been only slightly in excess of 25 000 miles. In June 1930, lubricator connections were added to the top guides and since that date it has not been necessary to touch the crossheads. In November 1930, connections were added to the valve-motion parts including all pins, the bottom end of the combination lever, union link, back end of union link and the crosshead pin which takes care of the front end main-rod bearing. At the end of 7 000 miles it was necessary to take

Lateral wear with forced-feed hub lubrication.

	28 July 1930 Mileage 24 131	1 Nov. 1930 Mileage 39 440	1 Feb, 1931 Mileage 53 094
Engine truck	No check.	9/32 inch.	13/32 inch.
No 1 front driver	1/4 inch.	15/32 —(1)	3/8 —
No. 2 front int. driver	1/4 —	5/16 —	7/16 —
No. 3 main driver	1/4 —	3/16 —(2)	1/4 —
No. 4 back int. driver	7/16 —	7/16 —	7/16 —
No. 5 back driver	1/4 —	1/4 —	5/16 —
Trailer-truck wheels	3/8 —	1/2 —	9/16 —

(1) This measurement was questioned but no recheck was made.
(2) Due to dropping of main wheels as mentioned above.

up the front-end brass on the main rod only 1/32 inch. Formerly these brasses had to be taken up approximately every 800 miles. The brass at the end of 7 000 miles was apparently in perfect condition and showed no signs of disintegration.

Records were kept of the amount of lubricant required over the period mentioned in the above table. During the period when only the hubs were lubricated the average was 71 miles per pint of lubricant for a total of 14 points lubricated. After the connections were added to the guides, making a total of 16 points, the average was 67 miles per pint. After the connections were extended to the other motion parts, making a total of 24 points, the average was 59 miles per pint of lubricant.

[385. (06 .111]

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Permanent Commission of the International Railway Congress Association,

74, rue du Progrès, BRUSSELS.

QUESTIONS

FOR DISCUSSION AT THE CAIRO SESSION (1933)

WITH

THE NAMES OF THE REPORTERS

Ist SECTION : WAY AND WORKS.

I. — The protection of level crossings in view of modern developments in road traffic.

Reporters :

America, Great Britain, Dominions and Colonies, China, Japan and Egypt :

Mr. NEWLANDS (M. A.), chief engineer, London Midland & Scottish Railway; Euston Station, London, N. W.

Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark Finland, Luxemburg, Norway, Sweden and Switzerland :

Mr. BATICLE, Directeur du Contrôle de l'Exploitation technique au Ministère des Travaux Publics de France; boulevard Saint-Germain, 244, Paris.

Other countries (Germany, Bulgaria, Greece, Rumania, Poland, Czechoslovakia, Turkey, Jugoslavia, etc.):

Mr. MISZKE (A.), ingénieur, chef du bureau des études et des projets au Ministère des Communications de Pologne; rue Langiewicza, 14, Warsaw.

II. — The use of mechanical appliances in the permanent way maintenance and in track relaying.

Reporters :

United States of America, Great Britain, Dominions and Colonies, China and Japan:

Mr. THOMSON (F. M.), district engineer, Missouri-Kansas-Texas Lines; Denison, Texas, U. S. A.

Mexico, Central and South America, Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway, Sweden and Switzerland :

Messrs. Mendizabal Fernandez (D.), sous-directeur de la Compagnie du Chemin de fer Madrid-Saragosse-Alicante; Estación de Atocha, Madrid, and

Garcia Garin (J.), chef du service du matériel fixe des voies et travaux des Chemins de fer du Nord de l'Espagne; Estacion del Norte, Madrid.

Other countries (Germany, Poland, Czechoslovakia, Bulgaria, Greece, Rumania, Jugoslavia, Turkey, Egypt, etc.):

Mohamed Bey Kamel El-Kishin, ingénieur divisionnaire, Chemins de fer de l'Etat égyptien; Zagazig (Egypt).

III. — The relationship between the vehicle and the track, to ensure safety at high speeds :

A) Weight of vehicles per axle, position of the centre of gravity, wheel arrangement, layout to facilitate running through curves.

B) Track resistance. Widening of gauge. Radius of curves. Superelevation. Transition curves. Points and crossings. Check rails.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Dr. Okhodo (S.), director of the Bureau of maintenance and improvement,

Dr. Matsunawa (S.), chief of the Railway Research Office, and

Dr. Asakura (K.), chief of the Rolling Stock Section : *all three* of the Department of Railways, Government of Japan; Tokyo.

Germany, Denmark, Finland, Norway, Spain, Netherlands, Portugal and their Colonies, Sweden and Switzerland :

Herr Prof. Baumann (H.), Direktor bei der Reichsbahn; Lammstrasse, 19, Karlsruhe, and

Herr Jähn (F.), Reichsbahnoberrat, Reichsbahn-Zentralamt; Hallesches Ufer, 35-36, Berlin, S. W. 11.

Other countries (Belgium, France, Italy and their Colonies, Luxemburg, Czechoslovakia, Poland, Bulgaria, Rumania, Greece, Turkey, Egypt, Jugoslavia, etc.):

Mr. Deyl (Hynek), conseiller ministériel et chef du département IV/5 au Ministère des Chemins de fer de Tchécoslovaquie; Prague.

2nd SECTION : LOCOMOTIVES AND ROLLING STOCK.

VI. — Methods to be used to increase the mileage run by locomotives between two repairs including lifting.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Sir Henry Fowler, K. B. E., assistant vice-president, Research and Development, London Midland & Scottish Railway (member of the Permanent Commission); Derby.

Germany, Denmark, Finland, Norway, Spain, Netherlands, Portugal and their Colonies, Sweden and Switzerland :

Herr Student (E.), Reichsbahndirektor, Deutsche Reichsbahn Gesellschaft; Vossstrasse, 35, Berlin, W. 8.

Other countries (Belgium, France, Italy and their Colonies, Luxemburg, Poland, Czechoslovakia, Bulgaria, Greece, Rumania, Jugoslavia, Turkey, Egypt, etc.):

Mr. Klatovsky (R.), ingénieur, conseiller ministériel et chef du département V/1 du Ministère des chemins de fer de Tchécoslovaquie; Prague II.

V. — Electrification of railways from an economic point of view. Selection of sites for generating stations. Choice of the kind of current. Safety precautions, etc.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Mr. Withington (S.), electrical engineer, New York, New Haven & Hartford Railroad; Newhaven, Conn. (U. S. A.).

Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway and Sweden :

Messrs. Leboucher, ingénieur en chef des services techniques du matériel et de la traction, Chemins de fer du Midi; boulevard Hausmann, 54, Paris (9e), and Japiot, ingénieur en chef adjoint du matériel et de la traction des Chemins de fer de Paris à Lyon et à la Méditerranée; boulevard Diderot, 20, Paris (12e).

Other countries (Germany, Poland, Switzerland, Czechoslovakia, Bulgaria, Greece, Rumania, Jugoslavia, Turkey, Egypt, etc.) :

Mr. Huber, ingénieur conseil des Chemins de fer Fédéraux suisses; Neumünster-Allee, 12, Zurich, and

Mr. Eckert, ingénieur, chef de section auprès de l'ingénieur en chef du service d'électrification des Chemins de fer fédéraux suisses; Berne.

VI. — All-metal rolling stock : carriages and wagons. Use of light metals and alloys. Use of autogeneous welding.

Reporters :

America, Great-Britain, Dominions and Colonies, China and Japan :

Mr. GRESLEY (H. N.), C. B. E., chief mechanical engineer, London & North Eastern Railway (member of the Permanent Commission); King's Cross Station, London, N. I.

Germany, Bulgaria, Denmark, Finland, Norway, Netherlands and Colonies, Rumania, Sweden, Czechoslovakia, and Turkey :

Herr DÄHNICK (E.), Reichsbahnoberrat, Deutsche Reichsbahn Gesellschaft, Zentralamt; Hallesches Ufer, 35-36, Berlin, S. W. 11.

Other countries (Belgium, Spain, France, Italy, Portugal and their Colonies, Luxemburg, Switzerland, Jugoslavia, Egypt, Greece, etc.):

Mr. MARIANI (R.), ingénieur, chef de service au service du matériel et de la traction, Chemins de fer de l'Etat italien; Viale Principessa Margherita, 52, Florence (12).

3rd SECTION : WORKING.

VII. — Allocation of freight rolling stock. Investigation into the turn-round of goods vehicles. Separation of the elements included in it. Methods of reducing the period of turn-round.

Reporters :

Belgium, Spain, France, Italy, Portugal and their Colonies, Luxemburg and Switzerland :

Mr. GAEREMYNCK (O.), ingénieur principal au service de l'exploitation de la Société Nationale des chemins de fer belges; 17, rue de Louvain, Brussels.

Germany, Denmark, Finland, Great Britain, Dominions and Colonies, Sweden, America, China and Japan, Norway, Netherlands and Colonies :

Mr. VAN RIJCKEVORSEL (F. H.), ingénieur, chef de service des transports des Chemins de fer néerlandais; Maliesingel, 76, Utrecht.

Other countries (Poland, Czechoslovakia, Bulgaria, Rumania, Jugoslavia, Greece, Turkey, Egypt, etc.) :

Mr. DOLINAR (J.), conseiller supérieur et chef du service de la répartition du matériel des Chemins de fer de l'Etat yougoslave; Nemanjina, 6, Belgrade.

VIII. — Organisation for carrying small consignments of goods and the most suitable methods for their delivery with the least delay. Use and selection of fixed and mechanical transhipping plants.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Mr. MINSART (E.), ingénieur principal à la Société nationale des chemins de fer belges; 74, rue du Progrès, Brussels.

Belgium, France, Spain, Netherlands, Portugal and their Colonies, Switzerland, Finland, Luxemburg, Norway and Sweden :

Messrs. HAUTERRE, chef de l'exploitation adjoint des Chemins de fer de l'Etat français, 13, rue d'Amsterdam, Paris (8e); and

MERMONT (M.), inspecteur général du mouvement du Chemin de fer de l'Est français; 13, rue d'Alsace, Paris (10e).

Other countries (Germany, Italy and Colonies, Poland, Czechoslovakia, Bulgaria, Rumania, Jugoslavia, Greece, Turkey, Egypt, etc.):

Mr. FETTARAPPA (C.), ingénieur, inspecteur en chef au service de l'exploitation des Chemins de fer de l'Etat italien, Rome.

IX. — Automatic train control and train stop. Track equipment. Locomotive fittings. Methods used for repeating signals on the locomotives. Devices intended to ensure the attention of the drivers.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Mr. CROOK (G. H.), assistant to signal engineer, Great Western Railway; Reading, England.

Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway and Sweden :

Mr. VLAÏKOFF (V.), ingénieur des signaux, Chemins de fer de l'Etat bulgare; 2, place de la Gare, Sofia.

Other countries (Germany, Poland, Czechoslovakia, Bulgaria, Greece, Rumania, Jugoslavia, Turkey, Egypt, etc.) :

Mr. STÄCKEL (W.), Reichsbahndirektor, Mitglied der Hauptverwaltung der Deutschen Reichsbahn-Gesellschaft; Vossstrasse, 35, Berlin, W. 8.

4th SECTION : GENERAL.

X. — Instances of the application in a railway department of the scientific organisation of work. Co-operation of the staff towards increased efficiency and its participation in the profits.

Reporters :

Belgium, Spain, France and their Colonies, Great Britain, Dominions and Colonies, Luxemburg, Netherlands, Portugal and their Colonies :

Messrs. Soulez (E.), ingénieur en chef attaché à la direction de l'exploitation du Chemin de fer du Nord français, rue de Dunkerque, 18*bis*, Paris (10e), and
Bloch, ingénieur en chef des services du matériel et des ateliers du Chemin de fer de Paris à Orléans; boulevard de la Gare, 41, Paris (13e).

Denmark, Norway, Sweden, Finland, Germany, Switzerland, Czechoslovakia, Bulgaria, Greece, Rumania, Jugoslavia, Turkey, Poland :

Mr. Mereutza, directeur général, Chemins de fer de l'Etat roumain (member of the Permanent Commission); 118, Calea Victoriei, Bucarest.

Italy and its Colonies and other countries :

Messrs. Tosti (L.), inspecteur en chef supérieur du service du personnel et des affaires générales, Chemins de fer de l'Etat italien; Rome, and
Valeri (C.), ingénieur, inspecteur en chef supérieur du service du matériel et de la traction, Chemins de fer de l'Etat italien; Florence.

XI. — Competition between or joint working of railways and airways, or railways and roadways.

An investigation from the technical, commercial and contractual point of view.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Mr. Cox (E. C.), traffic manager, Southern Railway; Waterloo Station, London S. E. 1.

Other countries :

Messrs. Villamil (F. P.), chef de la division commerciale du Chemin de fer du Nord de l'Espagne, Estación del Norte; Madrid, and
d'Ocón Cortes (E.), ingénieur au service commercial du Chemin de fer Madrid-Saragosse-Alicante; Estación de Atocha, Madrid.

5th SECTION : LIGHT RAILWAYS AND COLONIAL RAILWAYS.

XII. — Co-ordination of operation as between heavy and light railways.

Reporters :

Continent of Europe :

Mr. Jacobs (L.), directeur général adjoint, Société Nationale des Chemins de fer vicinaux de Belgique; rue de la Science, 14, Brussels.

Other countries :

Mohamed Sobhi Ishak Effendi, inspector and secretary, Light Railway Commission; Cairo, Egypt.

XIII. — Use of rail motor cars on secondary railway lines.

Reporters :

Italy and Colonies, Africa, (British Dominions and Colonies excepted), Mexico, Central and South America :

Messrs. La Valle (E.), inspecteur en chef, directeur du bureau central de conseil technique près l'Inspectorat général des chemins de fer, tramways et automobiles; Rome, and

Mellini (E.), ingénieur, inspecteur supérieur de l'Inspectorat général des chemins de fer, tramways et automobiles; Rome.

Continent of Europe (except Italy), Indo-China and Dutch Indies :

Mr. Level, directeur de la Compagnie générale de voies ferrées d'intérêt local; 18, rue de Dunkerque, Paris (10e).

Great Britain, Dominions and Colonies, United States of America, China and Japan:

Mr. Forster (A. D. J.), assistant railway Commissioner, New South Wales Government Railways, Box 29 A., G. P. O. Sydney, N. S. W., Australia.